Model Question Paper 1

Half-Yearly Examination 2026-27

SCIENCE

Time Allowed: 3 Hours **Maximum Marks: 80**

General Instructions:

1. This question paper has 5 sections: A, B, C, D and E.
2. Section A has 20 objective type questions carrying 1 mark each.
3. Section B has 6 questions carrying 2 marks each. Answers to these should not exceed 40-50 words each.
4. Section C has 7 questions carrying 3 marks each. Answers to these should not exceed 60-80 words each.
5. Section D has 3 questions carrying 5 marks each. Answers to these should not exceed 120 words each.
6. Section E has 3 source/case-based questions carrying 4 marks each with sub-parts.
7. There is no overall choice. However, internal choices have been provided in some questions. A student has to attempt only one of the choices in such questions.
8. Wherever necessary, neat and labelled diagrams should be drawn.

SECTION A

Question numbers 1 to 20 carry 1 mark each. Choose the most appropriate answer.

1. Before testing an idea through experiments, a scientist first frames a tentative, testable explanation based on existing observations. This tentative explanation is called a: *[1]*

(a) Law
(b) Hypothesis
(c) Theory
(d) Model

Answer: (b) — Hypothesis — a tentative, testable explanation proposed before experimentation.

2. A student wants to know roughly how many grains of rice are in a large sack without counting every single grain. She counts the grains in a small measured cup, then multiplies by the number of such cups the sack holds. This method of arriving at an approximate value is called: *[1]*

(a) Measurement
(b) Estimation
(c) Hypothesis testing
(d) Extrapolation error

Answer: (b) — Estimation — arriving at an approximate value using a representative sample and reasoning, without measuring everything directly.

3. The cell organelle that breaks down glucose to release energy for the cell's activities, and is therefore called the 'powerhouse of the cell', is the: *[1]*

(a) Nucleus
(b) Ribosome
(c) Mitochondria
(d) Golgi apparatus

Answer: (c) — Mitochondria — site of aerobic respiration, releasing energy as ATP.

4. Bacteria are classified as prokaryotic organisms mainly because their cells lack a: *[1]*

(a) Cell membrane
(b) Nuclear membrane enclosing the genetic material
(c) Cell wall
(d) Cytoplasm

Answer: (b) — A well-defined nucleus enclosed by a nuclear membrane; the genetic material lies free in the cytoplasm (nucleoid).

5. A dried raisin left overnight in a bowl of plain water swells up and becomes plump. This happens because water molecules move into the raisin's cells from a region of: *[1]*

(a) Lower water concentration outside to higher water concentration inside
(b) Higher water concentration outside to lower water concentration inside
(c) Equal concentration on both sides
(d) Higher solute concentration outside to lower solute concentration inside

Answer: (b) — Water moves by osmosis from the region of higher water concentration (plain water outside) to lower water concentration (concentrated cell sap inside).

6. The tissue found at the tip of a root or a shoot, whose cells divide continuously to bring about growth in length, is: *[1]*

(a) Permanent tissue
(b) Apical meristem
(c) Epithelial tissue
(d) Connective tissue

Answer: (b) — Apical meristem — located at growing tips, responsible for increase in length.

7. The thin, continuous layer of cells that lines the inner walls of blood vessels as well as the tiny air sacs (alveoli) of the lungs, allowing smooth flow of fluids and easy diffusion of gases, belongs to which type of tissue? *[1]*

(a) Muscular tissue
(b) Nervous tissue
(c) Epithelial tissue
(d) Connective tissue

Answer: (c) — Epithelial tissue — thin, closely packed cells forming linings/coverings suited for diffusion and smooth flow.

8. A gardener notices that when a stem is wounded, some fully mature, specialised cells near the cut regain the ability to divide repeatedly and form new tissue that seals the wound. This change of mature permanent cells back into a dividing (meristematic) state is called: *[1]*

(a) Differentiation
(b) Redifferentiation
(c) Dedifferentiation
(d) Specialisation

Answer: (c) — Dedifferentiation — mature permanent cells regain the capacity to divide.

9. A car covers equal distances in equal intervals of time while travelling along a straight highway. Its motion is best described as: *[1]*

(a) Non-uniform motion
(b) Uniform motion
(c) Accelerated motion
(d) Retarded motion

Answer: (b) — Uniform motion — equal distances in equal time intervals.

10. A cyclist covers a distance of 300 m in 1 minute while moving at a constant speed. Her speed is: *[1]*

(a) 3 m/s
(b) 5 m/s
(c) 18 m/s
(d) 0.2 m/s

Answer: (b) — Speed = distance/time = 300 m / 60 s = 5 m/s.

11. A scooter starting from rest accelerates uniformly at 2 m/s^2. The distance it covers in the first 5 seconds is: *[1]*

(a) 10 m
(b) 20 m
(c) 25 m
(d) 50 m
Answer: (c) — $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 2 \times 25 = 25$ m.

12. *This question consists of two statements — Assertion (A) and Reason (R). Choose the correct option: [1]*

Assertion (A): A car moving at a constant speed of 40 km/h around a circular roundabout is said to be undergoing accelerated motion.

Reason (R): Acceleration occurs whenever the velocity of a body changes, and velocity changes if either the speed or the direction of motion changes, even if speed alone stays constant.

(a) Both A and R are true, and R is the correct explanation of A
(b) Both A and R are true, but R is NOT the correct explanation of A
(c) A is true, but R is false
(d) A is false, but R is true
Answer: (a) — Both true; R correctly explains A — direction keeps changing on a circular path, so velocity (and hence acceleration) is non-zero even at constant speed.

13. Which of the following is a homogeneous mixture? *[1]*

(a) Sand and water
(b) Oil and water
(c) Sugar dissolved completely in water
(d) Milk
Answer: (c) — Sugar solution — uniform composition throughout, a true (homogeneous) solution.

14. Milk, fog and shaving cream all consist of particles that are larger than those in a true solution, do not settle down on standing, and scatter a beam of light passed through them. Such mixtures are classified as: *[1]*

(a) Suspensions
(b) Colloids
(c) True solutions
(d) Pure compounds
Answer: (b) — Colloids — intermediate particle size; show the Tyndall effect; do not settle on standing.

15. A chemist needs to separate two miscible liquids whose boiling points differ by only about 5°C. The most suitable technique for this is: *[1]*

(a) Simple distillation
(b) Fractional distillation
(c) Filtration
(d) Sublimation
Answer: (b) — Fractional distillation — used when boiling points of miscible liquids are close together.

16. The property of a body by virtue of which it resists any change in its state of rest or of uniform motion along a straight line is called: *[1]*

(a) Momentum
(b) Inertia
(c) Acceleration
(d) Gravity
Answer: (b) — Inertia — resistance to a change in the state of motion or rest.

17. A force of 10 N acts on a body of mass 2 kg that is initially at rest. The acceleration produced in the body is: *[1]*

(a) 2 m/s²
(b) 5 m/s²

(c) 10 m/s²
(d) 20 m/s²
Answer: (b) — a = F/m = 10/2 = 5 m/s².

18. *This question consists of two statements — Assertion (A) and Reason (R). Choose the correct option: [1]*

Assertion (A): A rocket is able to accelerate forward in empty space by expelling burnt gases at high speed from its rear nozzle.

Reason (R): According to Newton's third law of motion, the force with which the rocket pushes the gases backward is equal and opposite to the force with which the gases push the rocket forward.

(a) Both A and R are true, and R is the correct explanation of A
(b) Both A and R are true, but R is NOT the correct explanation of A
(c) A is true, but R is false
(d) A is false, but R is true
Answer: (a) — Both true; R correctly explains A (action-reaction pair between rocket and expelled gases).

19. Work is said to be done on an object by a force only when: *[1]*

(a) The force acts on the object but the object does not move at all
(b) The force causes a displacement of the object in the direction of the force (or a component of it)
(c) The force acts exactly perpendicular to the displacement
(d) The object moves due to its own inertia with no force acting
Answer: (b) — Work is done only when a force produces a displacement in the direction of the force (or a component along it).

20. A boy lifts a schoolbag of mass 5 kg from the floor to a shelf 2 m high, at a slow, constant speed. Taking g = 10 m/s², the work done by him against gravity is: *[1]*

(a) 10 J
(b) 50 J
(c) 100 J
(d) 250 J
Answer: (c) — W = mgh = 5 × 10 × 2 = 100 J.

SECTION B

Question numbers 21 to 26 carry 2 marks each.

21. State two differences between prokaryotic and eukaryotic cells on the basis of (a) the nuclear region and (b) membrane-bound organelles. *[2]*

Marking Scheme / Value Points:

• (a) Prokaryotic cells lack a nuclear membrane, so the genetic material lies free in the cytoplasm (nucleoid); eukaryotic cells have a true, membrane-bound nucleus — 1 mark
• (b) Prokaryotic cells lack membrane-bound organelles (e.g. mitochondria, Golgi body); eukaryotic cells possess well-developed membrane-bound organelles — 1 mark

22. A doctor examining an X-ray explains that bones are hard and rigid, while the flexible tip of the nose or the outer ear is made of a softer, bendable connective tissue. State two differences between bone and cartilage as connective tissues. *[2]*

Marking Scheme / Value Points:

• Bone has a hard, calcified (mineralised) matrix rich in calcium and phosphorus compounds, making it rigid; cartilage has a solid but flexible matrix — 1 mark
• Bone provides the rigid framework/support for the body and attachment for muscles; cartilage smoothens joint surfaces and provides flexible support (e.g. nose, ear, trachea) — 1 mark

23. A car's speed increases uniformly from 20 m/s to 32 m/s in 6 seconds. Calculate its acceleration. *[2]*

Marking Scheme / Value Points:

- a = (v − u)/t = (32 − 20)/6 — 1 mark
- a = 12/6 = 2 m/s² — 1 mark

24. A shopkeeper accidentally mixes iron filings with sulphur powder while packing chemicals. Suggest a suitable method to separate them and explain briefly why it works. *[2]*

Marking Scheme / Value Points:

- Method: pass a magnet over/through the mixture — 1 mark
- Reason: iron filings are magnetic and get attracted to and picked up by the magnet, while sulphur powder (non-magnetic) is left behind — 1 mark

25. A truck of mass 2000 kg moving at 20 m/s is brought to rest by applying brakes for 5 seconds. Calculate (a) its acceleration (deceleration), and (b) the force applied by the brakes. *[2]*

Marking Scheme / Value Points:

- (a) a = (0 − 20)/5 = −4 m/s² (deceleration of 4 m/s²) — 1 mark
- (b) F = ma = 2000 × 4 = 8000 N — 1 mark

26. A crane does 6000 J of work in lifting a load through a height of 3 m. Taking g = 10 m/s², calculate the weight of the load. *[2]*

Marking Scheme / Value Points:

- W = (weight) × h ⇒ weight = W/h = 6000/3 — 1 mark
- Weight of load = 2000 N — 1 mark

SECTION C

Question numbers 27 to 33 carry 3 marks each.

27. A student measures the length of her classroom five times with a metre scale and obtains the readings: 8.20 m, 8.22 m, 8.19 m, 8.21 m and 8.23 m. (a) Calculate the mean (average) value of the length. (b) Give one reason why scientists prefer to take several repeated readings rather than rely on a single measurement. *[3]*

Marking Scheme / Value Points:

- (a) Mean = (8.20+8.22+8.19+8.21+8.23)/5 = 41.05/5 = 8.21 m — 1.5 marks
- (b) A single reading may be affected by small random errors (in the instrument, or in how it is read); taking several readings and averaging reduces the effect of such errors and gives a more reliable value — 1.5 marks

28. With reference to cell organelles: (a) Name the organelle that packages and dispatches materials manufactured within the cell. (b) Name the organelle responsible for intracellular digestion of unwanted material. (c) Explain briefly why the mitochondrion is called the 'powerhouse of the cell'. *[3]*

Marking Scheme / Value Points:

- (a) Golgi apparatus/Golgi body — 1 mark
- (b) Lysosome — 1 mark
- (c) It is the site of aerobic respiration, breaking down food (glucose) to release energy that is stored in a usable form (ATP) for the cell's activities — 1 mark

29. Differentiate between striated (skeletal), unstriated (smooth) and cardiac muscle tissue on the basis of (a) shape of cells and (b) whether their action is voluntary or involuntary. *[3]*

Marking Scheme / Value Points:

- Striated/skeletal muscle: long, cylindrical, multinucleate fibres with visible bands; voluntary (attached to bones, moved consciously) — 1 mark
- Unstriated/smooth muscle: long, spindle-shaped, uninucleate cells, no bands; involuntary (found in stomach, intestine, blood vessels) — 1 mark

• Cardiac muscle: cylindrical, branched, uninucleate fibres with faint bands; involuntary and rhythmic (found only in the heart) — 1 mark

30. A ball is thrown vertically upward with an initial velocity of 20 m/s. Taking g = 10 m/s² as the retardation acting on it, calculate (a) the maximum height it reaches, and (b) the time taken to reach the highest point. *[3]*

Marking Scheme / Value Points:

• (a) Using $v^2 = u^2 - 2gh$, at highest point v = 0: $0 = (20)^2 - 2(10)h \Rightarrow h = 400/20 = 20$ m — 1.5 marks

• (b) Using $v = u - gt$, $0 = 20 - 10t \Rightarrow t = 2$ s — 1.5 marks

31. A tea-stall vendor boils tea leaves, milk, sugar and water together, then pours the tea through a fine strainer before serving. (a) Name the separation technique used here. (b) Explain briefly why this technique separates out the tea leaves but cannot separate the sugar dissolved in the tea. *[3]*

Marking Scheme / Value Points:

• (a) Filtration — 1 mark

• (b) The tea leaves are undissolved solid particles large enough to be retained by the strainer/filter, whereas the dissolved sugar forms a true (homogeneous) solution with particles far too small to be retained by any filter — 2 marks

32. A ball of mass 2 kg moving at 6 m/s collides with a stationary ball of mass 4 kg moving in the same direction. After the collision, the first ball continues moving at 4 m/s in the same direction. Using the law of conservation of momentum, calculate the velocity of the second ball after the collision. *[3]*

Marking Scheme / Value Points:

• Total momentum before collision = (2 × 6) + (4 × 3) — here state clearly: momentum before = 2×6 + 4×3 = 12+12 = 24 kg m/s — 1 mark

• Momentum after collision = (2 × 4) + (4 × v) = 8 + 4v; by conservation, 8 + 4v = 24 — 1 mark

• Solving: 4v = 16 ⇒ v = 4 m/s — 1 mark

33. A pendulum bob is pulled to one side and released, so it swings back and forth. (a) At the extreme positions of the swing, which form of mechanical energy is maximum, and why? (b) At the lowest (mean) position, which form of energy is maximum, and why? (c) State how this illustrates the law of conservation of energy. *[3]*

Marking Scheme / Value Points:

• (a) Potential energy is maximum at the extreme positions, since the bob is momentarily at rest (zero speed) and at its greatest height — 1 mark

• (b) Kinetic energy is maximum at the mean position, since the bob is moving at its greatest speed there — 1 mark

• (c) As the bob swings, potential energy continuously converts into kinetic energy and back, but the total mechanical energy (PE + KE) at any instant remains constant (ignoring air resistance/friction), illustrating that energy is neither created nor destroyed, only transformed — 1 mark

SECTION D

Question numbers 34 to 36 carry 5 marks each.

34. A car travels from Town A to Town B, 60 km apart, in 1.5 hours at a steady speed. Due to heavy traffic, it returns from B to A along the same route in 2 hours. (a) Calculate the average speed for the onward journey. (b) Calculate the average speed for the return journey. (c) Calculate the average speed for the entire round trip. (d) Explain briefly why the average speed for the whole trip is NOT simply the arithmetic mean of the two speeds found in (a) and (b). *[5]*

OR

A block of mass 10 kg is placed on a horizontal frictionless surface, and a constant horizontal force of 25 N is applied to it. (a) Calculate the acceleration produced. (b) If this force acts for 4 seconds starting from rest, calculate the final velocity attained by the block. (c) Calculate the distance covered by the block in these 4 seconds. (d) State Newton's second law of motion in the form F = ma, and briefly explain what each symbol represents.

Marking Scheme / Value Points:

- (a) Onward speed = 60 km / 1.5 h = 40 km/h — 1 mark
- (b) Return speed = 60 km / 2 h = 30 km/h — 1 mark
- (c) Average speed for round trip = total distance/total time = (60+60)/(1.5+2) = 120/3.5 ≈ 34.3 km/h — 1.5 marks
- (d) The car does NOT spend equal time at each speed — it spends more time (2 h) travelling at the slower speed (30 km/h) than at the faster one (1.5 h at 40 km/h). Average speed depends on total distance and total time, not on simply averaging the two speed values (35 km/h), so it comes out closer to (and below) the simple average — 1.5 marks

OR (value points):

- (a) $a = F/m = 25/10 = 2.5$ m/s² — 1 mark
- (b) $v = u + at = 0 + 2.5 \times 4 = 10$ m/s — 1 mark
- (c) $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 2.5 \times 16 = 20$ m — 1.5 marks
- (d) The rate of change of momentum of a body is directly proportional to the applied unbalanced force and takes place in the direction of the force; F is the net force, m is the mass of the body, and a is the acceleration produced — 1.5 marks

35. A pump is used to lift 300 kg of water through a height of 10 m in 25 seconds. Taking g = 10 m/s², calculate: (a) the work done in lifting the water. (b) the power of the pump in watts. (c) the power of the pump in kilowatts. (d) State the law of conservation of energy, and identify the main energy transformation taking place in this process. *[5]*

OR

A worker uses a simple lever to lift a heavy stone of weight 600 N by applying an effort of 100 N at the other end. (a) Calculate the mechanical advantage of the lever. (b) If the effort arm is 1.5 m long, calculate the load arm, using the principle that load × load arm = effort × effort arm. (c) Define mechanical advantage. (d) Give one reason why simple machines like levers are useful in everyday life even though they do not reduce the total work that must be done.

Marking Scheme / Value Points:

- (a) W = mgh = 300 × 10 × 10 = 30000 J — 1.5 marks
- (b) P = W/t = 30000/25 = 1200 W — 1 mark
- (c) 1200 W = 1.2 kW — 0.5 mark
- (d) Energy can neither be created nor destroyed, only transformed from one form to another, the total energy remaining constant; here, electrical energy supplied to the pump's motor is transformed into mechanical work/potential energy of the raised water (with some loss as heat/sound) — 2 marks

OR (value points):

- (a) Mechanical advantage = Load/Effort = 600/100 = 6 — 1 mark
- (b) 600 × load arm = 100 × 1.5 = 150 ⇒ load arm = 0.25 m — 1.5 marks
- (c) Mechanical advantage is the ratio of the load lifted to the effort applied — 1 mark
- (d) Machines allow a trade-off between force and distance (a small effort applied over a larger distance can lift a large load through a small distance), making tasks that would otherwise require a very large force possible/convenient, even though the work output can never exceed the work input — 1.5 marks

36. A student places three similar-sized potato cubes in three beakers: Beaker A with distilled water, Beaker B with a concentrated salt solution, and Beaker C with a salt solution whose concentration is the same as the potato cell sap. After two hours, she compares the size of each cube. (a) Predict and explain what happens to the cube in Beaker A. (b) Predict and explain what happens to the cube in Beaker B. (c) Predict what happens in Beaker C, and explain why. (d) Name the process responsible for these changes and define it. *[5]*

OR

A cross-section of a young dicot stem examined under a microscope shows: an outer single layer of closely packed cells; several layers of large, thin-walled cells with unusually thickened corners just beneath it; scattered vascular bundles (each containing two types of conducting tissue); and a central region of loosely packed cells. (a) Identify the outermost layer and state its main function. (b) Identify the thick-cornered tissue and state one function that suits its structure. (c) Name the two conducting tissues found in each vascular bundle and state one

substance each transports. (d) Explain how the structure of xylem vessels (dead, hollow, lignified cells joined end to end) suits their function.

Marking Scheme / Value Points:

- (a) The cube swells slightly/becomes firmer, because distilled water has a higher water concentration than the cell sap (a hypotonic solution), so water moves into the potato cells — 1 mark
- (b) The cube shrinks and becomes limp, because the concentrated salt solution has a lower water concentration than the cell sap (a hypertonic solution), so water moves out of the potato cells (plasmolysis) — 1.5 marks
- (c) There is no significant change in size, because the surrounding solution is isotonic to the cell sap, so there is no net movement of water into or out of the cells — 1 mark
- (d) Osmosis — the movement of water molecules from a region of higher water concentration to a region of lower water concentration through a semi-permeable membrane — 1.5 marks

OR (value points):

- (a) Epidermis; protects the internal tissues from water loss, mechanical injury and entry of pathogens — 1 mark
- (b) Collenchyma; provides flexible mechanical support to growing parts such as young stems and leaf petioles (allows bending without breaking) — 1 mark
- (c) Xylem transports water and dissolved minerals from roots upward; Phloem transports food (mainly sucrose) manufactured in the leaves to other parts of the plant — 1.5 marks
- (d) Xylem vessels are dead (offer no cytoplasmic resistance), hollow and joined end to end forming continuous tubes, and are lignified for mechanical strength — this structure allows the smooth, continuous, one-way upward conduction of large volumes of water under tension — 1.5 marks

SECTION E

Question numbers 37 to 39 are source/case-based questions carrying 4 marks each with four sub-parts each.

Case Study 1 — Question 37 [4 Marks]

At a school science fair, a group of students is given a sample of muddy pond water, a mixture of common salt and sand, and a sample of black ink, and asked to separate/purify each using techniques they have learnt in the chapter on mixtures and separation.

(i) Name the technique the students should use first to remove the visible mud/suspended particles from the pond water. *[1]*

Answer: Filtration (passing the water through filter paper); sedimentation followed by decantation is also acceptable.

(ii) Suggest a method to obtain pure drinking water free of dissolved salts from the filtered pond water, and briefly state the principle involved. *[1]*

Answer: Distillation — the water is heated to its boiling point and vaporised, and the vapour is cooled and condensed back into pure liquid water in a separate vessel, leaving the dissolved salts (which do not vaporise) behind.

(iii) Describe briefly how the students should separate the mixture of common salt and sand. *[1]*

Answer: Add water to the mixture to dissolve the salt (sand is insoluble); filter to remove the sand; then evaporate the filtrate (salt solution) to recover salt crystals.

(iv) Name and briefly describe the technique the students should use to separate the different coloured dyes present in the black ink sample. *[1]*

OR Common salt and ammonium chloride are both soluble in water and cannot be separated efficiently by evaporation alone. Explain why, and name the technique you would recommend instead.

Answer: Chromatography — a spot of ink is placed near one end of a strip of chromatography/filter paper, which is then dipped (below the spot) in a suitable solvent; as the solvent rises up the paper by capillary action, the different dye components travel at different rates according to their solubility, separating into distinct coloured bands.

OR Answer: On heating, ammonium chloride sublimes (turns directly into vapour) and would be lost along with the water vapour instead of remaining behind like the salt; sublimation should be used to separate ammonium chloride (which sublimes on heating) from common salt (which does not).

Case Study 2 — Question 38 [4 Marks]

A cyclist starts from rest and rides along a straight road. A sports app on his phone plots his velocity against time: from t = 0 s to t = 4 s his velocity increases uniformly from 0 to 8 m/s; from t = 4 s to t = 10 s his velocity stays constant at 8 m/s; and from t = 10 s to t = 12 s he brakes and his velocity uniformly drops from 8 m/s to 0.

(i) Calculate the cyclist's acceleration during the first 4 seconds. *[1]*

Answer: a = (8 − 0)/4 = 2 m/s².

(ii) What type of motion does the cyclist have between t = 4 s and t = 10 s? Calculate the distance covered in this interval. *[1]*

Answer: Uniform (constant-velocity) motion; distance = speed × time = 8 × 6 = 48 m.

(iii) Calculate the cyclist's retardation (deceleration) while braking, between t = 10 s and t = 12 s. *[1]*

Answer: a = (0 − 8)/2 = −4 m/s², i.e. a retardation of 4 m/s².

(iv) Calculate the total distance covered by the cyclist during the entire 12-second journey. *[1]*

OR Describe the shape of the distance-time graph you would expect for the constant-velocity phase (t = 4 s to t = 10 s) of this journey, and justify its shape.

Answer: Distance in 0-4 s = ½ × 4 × 8 = 16 m; distance in 4-10 s = 48 m; distance in 10-12 s = ½ × 2 × 8 = 8 m. Total = 16 + 48 + 8 = 72 m.

OR Answer: A straight line sloping upward at a constant angle (constant slope), because distance increases uniformly with time at constant velocity; the slope of this line equals the cyclist's velocity, 8 m/s.

Case Study 3 — Question 39 [4 Marks]

Modern cars are fitted with seat belts and airbags. During a sudden collision, a car moving at high speed stops abruptly, but an unbelted passenger continues moving forward due to inertia and may strike the dashboard or windscreen. Seat belts and airbags are designed to increase the time over which the passenger's momentum changes, thereby reducing the force experienced.

(i) Which of Newton's laws explains why an unbelted passenger keeps moving forward when the car stops suddenly? *[1]*

Answer: Newton's first law of motion (the law of inertia) — a body continues in its state of rest or uniform motion unless acted upon by an external unbalanced force.

(ii) Using the relationship between force, change in momentum and time taken, explain why increasing the time taken to stop the passenger (using a seat belt/airbag) reduces the force experienced. *[1]*

Answer: Force = (change in momentum)/(time taken), i.e. F = Δp/Δt. For a given change in momentum Δp, increasing the time Δt over which it occurs decreases the force F experienced by the passenger.

(iii) State Newton's second law of motion in words. *[1]*

Answer: The rate of change of momentum of a body is directly proportional to the unbalanced (net) force applied on it, and the change in momentum takes place in the direction of the applied force.

(iv) A passenger of mass 70 kg, moving at 20 m/s, is brought to rest in 0.2 s by an airbag. Calculate the average force exerted on the passenger by the airbag. *[1]*

OR If the same passenger, without a seat belt or airbag, were instead stopped by hitting the dashboard in just 0.02 s, calculate the average force experienced, and comment on why this would be more dangerous.

Answer: Change in momentum = mΔv = 70 × 20 = 1400 kg m/s; F = Δp/Δt = 1400/0.2 = 7000 N.

OR Answer: F = Δp/Δt = 1400/0.02 = 70000 N. Since the same change in momentum now occurs over a much shorter time, the force is ten times larger (70,000 N vs 7,000 N) — this illustrates why seat belts and airbags, which increase the stopping time, greatly reduce the risk of injury.