SCIENCE (PHYSICS) – Paper 2 Physics (set 2.3) – mark scheme

Use this to mark your own attempt. Accept any correct alternative that answers the question as set. Marks are for the ideas, not the exact words. Unless stated, ecf (error carried forward) applies in calculations. Chermistry practice paper – not an official examination paper.

Total marks: 65 (Section A: 55 marks; Section B: one question of 10 marks)

Textbook references are quoted word for word from *Discover Physics, 5th ed*.

Section A – Question 1 [3]

Part	Answer and mark points	Marks
1(a)	the displacement is zero (1) because displacement is a vector: the 40 km east and the 40 km west cancel / the train ends where it started; the distance travelled (80 km) is a scalar that adds up the whole path whatever the direction (zero and the reason both needed) **Accept:** displacement = 0 km because the train returns to its starting point. Not accepted: 80 km or 40 km as the displacement **Textbook: Discover Physics, 5th ed., p. 12 (Ch 1, 1.4 What Are Scalars and Vectors?)** *"Vector quantities are physical quantities that have both magnitude and direction."* **Textbook: Discover Physics, 5th ed., p. 12 (Ch 1, 1.4 What Are Scalars and Vectors?)** *"Its displacement is zero, because it returns to A."*	1
1(b)	• A: non-contact (the floating train is not touching the track) (1 mark for any two correct) • B: contact (the surfaces touch); C: non-contact (Earth does not touch the train) (2 marks for all three correct) **Accept:** A: magnetic force is a non-contact force. B is the normal force from the track **Textbook: Discover Physics, 5th ed., p. 47 (Ch 3 Force and Pressure, Types of Forces)** *"This type of force between objects that are in contact is known as contact force."* **Textbook: Discover Physics, 5th ed., p. 48 (Ch 3 Force and Pressure, Types of Forces)** *"Non-contact forces are those that do not require objects to be in contact to exist."*	2

Section A – Question 2 [5]

Part	Answer and mark points	Marks
2(a)	• the Earth has a gravitational field, a region in which a mass experiences a force due to gravitational attraction (1) • the crate (which has mass) is in this field so it experiences a (downward) gravitational force, which is its weight (1) **Textbook: Discover Physics, 5th ed., p. 50 (Ch 3 Force and Pressure, Gravitational Field)** *"A gravitational field is a region in which a mass experiences a force due to gravitational attraction."*	2
2(b)	gravitational force per unit mass (placed at that point) **Accept:** force on a 1 kg mass in the field **Textbook: Discover Physics, 5th ed., p. 51 (Ch 3 Force and Pressure, Gravitational Field Strength)** *"Gravitational field strength g is defined as the gravitational force per unit mass placed at that point."*	1

2(c)	• the mass of the crate is 600 / 10 = **60 kg** on Earth, and the mass (amount of matter) does not change with place, so it is 60 kg on the Moon (1) • the student divided by 10 N/kg, but the gravitational field strength on the Moon is smaller (1.6 N/kg): weight depends on the gravitational field strength, mass does not (96 / 1.6 = 60 kg) (1) **Accept:** the Moon has a weaker gravitational field, so the crate weighs less but its mass is the same (the value 1.6 N/kg is not given in the question and need not be quoted). Not accepted: "the crate has less matter on the Moon" **Textbook: Discover Physics, 5th ed., p. 49 (Ch 3 Force and Pressure, Mass)** > *"Mass is a measure of the amount of matter in a body."* **Textbook: Discover Physics, 5th ed., p. 51 (Ch 3 Force and Pressure, Gravitational Field Strength)** > *"On the other hand, the same 1 kg mass on the moon experiences a gravitational force of only 1.6 N. This is because the gravitational field strength on the moon is 1.6 N/kg."* **Textbook: Discover Physics, 5th ed., p. 51 (Ch 3 Force and Pressure, Gravitational Field Strength)** > *"The elephant would weigh much more on Earth's surface than on the moon's surface even though its mass remains unchanged."*	2

Section A – Question 3 [4]

Part	Answer and mark points	Marks
3(a)	• resultant force on the wagon = ma = 20 000 × 0.30 = 6000 N (1) • coupling force = resultant force + resistive force on the wagon = 6000 + 2000 = **8000 N** (1) **Accept:** via the locomotive: 24 000 − 4000 − T = 40 000 × 0.30 gives T = 8000 N (2 marks). Not accepted: 6000 N (forgets the resistive force on the wagon); 12 000 N (uses the locomotive's mass with the wagon's forces)	2
3(b)	• water reduces the friction between the wheels and the rails, so the (braking) resultant force on the train is smaller (1) • the train's mass is the same so (a = F/m) the deceleration is smaller: the speed falls more slowly, so it needs a longer time and distance to stop (1) **Accept:** less friction, so less resultant force opposing the motion, so smaller deceleration **Textbook: Discover Physics, 5th ed., p. 74 (Ch 4 Dynamics, Friction and Its Effects)** > *"Friction opposes motion between surfaces in contact."* **Textbook: Discover Physics, 5th ed., p. 76 (Ch 4 Dynamics, Enhancing Positive Effects of Friction)** > *"Friction enables the tyres to grip the road surface and roll without slipping."*	2

Section A – Question 4 [3]

Part	Answer and mark points	Marks
4(a)	when a body is in equilibrium, the sum of the clockwise moments about a pivot equals the sum of the anticlockwise moments about the same pivot **Textbook: Discover Physics, 5th ed., p. 85 (Ch 5 Turning Effects of Forces)** > *"The principle of moments states that when a body is in equilibrium, the sum of clockwise moments about a pivot is equal to the sum of anticlockwise moments about the same pivot."*	1
4(b)	• clockwise moment of the arm and the lamp = 90 × 1.5 + 20 × 3.5 = 135 + 70 = 205 N m (1) • W × 0.50 = 205 so W = **410 N** (1) **Accept:** correct substitution with distances in cm. ecf for a wrong first line. Not accepted: 270 N (lamp ignored)	2

Section A – Question 5 [4]

Part	Answer and mark points	Marks
5(a)	• kinetic energy lost = $\frac{1}{2}mv^2 = \frac{1}{2} \times 12\,000 \times 20^2 = 2.4 \times 10^6$ J and gravitational potential energy gained = $mgh = 12\,000 \times 10 \times 15 = 1.8 \times 10^6$ J (1) • energy transferred to the thermal store = $2.4 \times 10^6 - 1.8 \times 10^6 =$ **6.0×10^5 J** (1) **Accept:** kinetic energy lost = gravitational potential energy gained + thermal energy. Not accepted: 1.8×10^6 J or 2.4×10^6 J alone **Textbook: Discover Physics, 5th ed., p. 108 (Ch 6 Energy)** > *"The principle of conservation of energy states that energy cannot be created or destroyed. Energy can be transferred from one store to another. The total energy of an isolated system is constant."*	2
5(b)	• energy transferred between 20 s and 50 s = $(7.5 - 2.4) \times 10^6 = 5.1 \times 10^6$ J in 50 − 20 = 30 s (1) • power = energy / time = $5.1 \times 10^6 / 30 =$ **1.7×10^5 W** (170 kW) (1) **Accept:** any valid working that gives 1.7×10^5 W. Not accepted: $7.5 \times 10^6 / 50 = 1.5 \times 10^5$ W (whole 50 s, not the interval asked); $2.4 \times 10^6 / 20 = 1.2 \times 10^5$ W (first 20 s only); $7.5 \times 10^6 / 30$ (energy not subtracted) **Textbook: Discover Physics, 5th ed., p. 115 (Ch 6 Energy, Power)** > *"Power is defined as the work done or energy transferred per unit time."*	2

Section A – Question 6 [4]

Part	Answer and mark points	Marks
6(a)	• brake fluid is **P** (a liquid: fixed volume, no fixed shape, density less than a solid); air is **Q** (a gas: no fixed volume, no fixed shape, lowest density); steel is **R** (a solid: fixed shape and fixed volume, highest density) • 2 marks for all three correct; 1 mark for two correct **Accept:** liquid / gas / solid for P / Q / R **Textbook: Discover Physics, 5th ed., p. 125 (Ch 7 Kinetic Particle Model of Matter, Table 7.1)** > *"Solids have a fixed volume and a fixed shape."* **Textbook: Discover Physics, 5th ed., p. 125 (Ch 7 Kinetic Particle Model of Matter, Table 7.1)** > *"Liquids have a fixed volume and no fixed shape."* **Textbook: Discover Physics, 5th ed., p. 125 (Ch 7 Kinetic Particle Model of Matter, Table 7.1)** > *"Gases have no fixed volume (compressible) and no fixed shape. A gas takes up the volume and shape of its container."* **Textbook: Discover Physics, 5th ed., p. 125 (Ch 7 Kinetic Particle Model of Matter, Table 7.1)** > *"Gases have the lowest densities."*	2
6(b)	• brake fluid (liquid): particles are close together and slide over each other; air (gas): particles are very far apart and move freely in any direction (1) • in the gas there is a lot of empty space between the particles so they can be pushed much closer together; in the liquid the particles are already close together (touching) so they cannot be pushed closer (1) **Accept:** a correct difference in spacing and a correct difference in motion are both needed for the first mark **Textbook: Discover Physics, 5th ed., p. 125 (Ch 7 Kinetic Particle Model of Matter, Table 7.1)** > *"Particles are slightly less closely packed than in solids and arranged in an irregular pattern."* **Textbook: Discover Physics, 5th ed., p. 125 (Ch 7 Kinetic Particle Model of Matter, Table 7.1)** > *"The particles slide over each other throughout the liquid without fixed positions."* **Textbook: Discover Physics, 5th ed., p. 125 (Ch 7 Kinetic Particle Model of Matter, Table 7.1)** > *"Particles are very far apart from one another in an irregular pattern."* **Textbook: Discover Physics, 5th ed., p. 125 (Ch 7 Kinetic Particle Model of Matter, Table 7.1)** > *"The particles can move freely in any direction."*	2

Section A – Question 7 [5]

Part	Answer and mark points	Marks
7(a)	the metal contains free electrons which move very fast through the metal and transfer energy (by collisions), in addition to the vibrations of the atoms; plastic has no free electrons so energy passes on only by the slower vibrations of the particles (the free electrons idea is needed for the mark) **Accept:** free electrons gain energy and move through the metal, colliding with atoms and passing the energy on **Textbook: Discover Physics, 5th ed., p. 137 (Ch 8 Thermal Processes, Conduction in Solids)** *"However, metals consist of tiny particles called free electrons that are absent in most non-metals."* **Textbook: Discover Physics, 5th ed., p. 137 (Ch 8 Thermal Processes, Conduction in Solids)** *"Due to their small size and high speed, the free electrons move very fast through the metal and transfer energy easily."*	1
7(b)	• the air next to the dashboard has a lower density (1.06 kg/m^3) than the cooler air around it (1.20 kg/m^3) (because it has expanded), so it rises (1) • the cooler, denser air sinks to take its place; this repeats and the air circulates, forming a convection current (1) **Accept:** warm air less dense so it rises; cool air denser so it sinks and replaces it **Textbook: Discover Physics, 5th ed., p. 139 (Ch 8 Thermal Processes, Convection)** *"The warm liquid, being less dense than its surroundings, will rise. The cold liquid, being denser, will sink."* **Textbook: Discover Physics, 5th ed., p. 139 (Ch 8 Thermal Processes, Convection)** *"At the same time, the surrounding denser liquid sinks to take the place of the rising liquid."*	2
7(c)(i)	space is a vacuum / there is no material medium; (the energy travels as) radiation (electromagnetic waves), which does not need a medium **Textbook: Discover Physics, 5th ed., p. 140 (Ch 8 Thermal Processes, Radiation)** *"Radiation is the process of energy transfer by electromagnetic waves. It does not require a medium."*	1
7(c)(ii)	the black (dark, matt) surface absorbs radiation at a faster rate than the white (light, shiny) surface, so more energy is absorbed each second by the black car **Accept:** white surface reflects more radiation **Textbook: Discover Physics, 5th ed., p. 142 (Ch 8 Thermal Processes, Surface Colour and Texture)** *"The shiny, smooth and light-coloured surface of an object absorbs incoming radiation at a slower rate. The same surface also emits radiation at a slow rate. Hence, a poor emitter of radiation is also a poor absorber of radiation. The reverse is true for matt, rough and dark-coloured surfaces."*	1

Section A – Question 8 [5]

Part	Answer and mark points	Marks
8(a)	• the vibrating disc (source) produces the sound (1) • sound needs a medium (particles of air) to pass on the vibrations; with the air removed (a vacuum) there are no particles to pass the vibrations from the disc to the glass and outside (1) **Textbook: Discover Physics, 5th ed., p. 172 (Ch 10 General Wave Properties II, Sound, 10.1)** *"Sound is a longitudinal wave created by a vibrating source."* **Textbook: Discover Physics, 5th ed., p. 173 (Ch 10 General Wave Properties II, Sound, Transmission of Sound)** *"This is because there is no medium to transmit sound waves. Sound travels when the vibrations of atoms are passed on to neighbouring atoms."*	2

8(b)	• Fig. 8.1 shows 4 complete waves in 34 mm, so the wavelength = 34 / 4 = 8.5 mm = 0.0085 m (1) • $v = f\lambda$ = 40 000 × 0.0085 = **340 m/s** (1) **Accept:** wavelength read from one cycle (for example crest to crest) as 8.5 mm. Not accepted: 34 mm used as the wavelength (1 360 000 mm/s or 1360 m/s); wavelength not converted to metres (8.5 × 40 000 = 340 000) scores 1 only if the unit is mm/s	2
8(c)	the pulse transfers energy (not matter); the air particles only vibrate about their fixed positions, they do not travel with the wave (both parts needed) (1) **Textbook: Discover Physics, 5th ed., p. 156 (Ch 9 General Wave Properties I, Waves)** *"A wave is a disturbance that propagates through space, transferring energy with it but not matter."*	1

Section A – Question 9 [3]

Part	Answer and mark points	Marks
9(a)	microwaves, infrared, visible light, ultraviolet, X-rays (2 marks for all five in the correct order; 1 mark if only two neighbouring waves are swapped) **Accept:** order of increasing frequency is the reverse of the order of increasing wavelength (X-rays have the shortest wavelength) **Textbook: Discover Physics, 5th ed., p. 185 (Ch 11 Electromagnetic Waves)** *"In the electromagnetic spectrum, electromagnetic waves are arranged in order of their frequency or wavelength."*	2
9(b)	X-rays have a higher frequency and are ionising: they penetrate the body and knock electrons out of atoms and molecules in cells (making ions), which can kill cells or cause mutations / cancer; infrared radiation does not ionise (it only has a heating effect) (X-rays ionising / damage cells, and a contrast with infrared, both needed) **Accept:** X-rays penetrate deeper into the body and create ions, so they are more harmful **Textbook: Discover Physics, 5th ed., p. 196 (Ch 11 Electromagnetic Waves, 11.2)** *"The high-energy ionising radiations can knock electrons out from atoms and molecules to create harmful ions."* **Textbook: Discover Physics, 5th ed., p. 196 (Ch 11 Electromagnetic Waves, 11.2)** *"As higher frequency electromagnetic waves can penetrate deeper into the body to create ions, they are more harmful than radiations which do not penetrate as deeply."*	1

Section A – Question 10 [5]

Part	Answer and mark points	Marks
10(a)	angle of incidence = 90 − 35 = 55° (measured from the normal), angle of reflection = 55°, so the angle between the incident ray and the reflected ray = 55 + 55 = **110°** **Accept:** 110°. Not accepted: 70° (35 + 35); 55° (one angle only) **Textbook: Discover Physics, 5th ed., p. 201 (Ch 12 Light, Laws of Reflection)** *"The perpendicular line (90 °) to the surface at the point of incidence is called the normal."* **Textbook: Discover Physics, 5th ed., p. 202 (Ch 12 Light, Laws of Reflection)** *"The second law of reflection states that the angle of incidence θi is equal to the angle of reflection θr."*	1

10(b)	• a normal drawn at P, perpendicular to the glass surface (1) • angle *i* marked between the incident ray and the normal, and angle *r* marked between the refracted ray inside the glass and the normal, both labelled (1) **Textbook: Discover Physics, 5th ed., p. 201 (Ch 12 Light, Laws of Reflection)** > *"The angle between the incident ray and the normal is called the angle of incidence (θi)."* **Textbook: Discover Physics, 5th ed., p. 209 (Ch 12 Light, Refraction)** > *"The angle of refraction is the angle between the refracted ray and the normal at the point of incidence."*	2
10(c)(i)	the ratio of the speed of light in a vacuum to the speed of light in the medium **Accept:** n = c / v; also sin *i* / sin *r* (light going from a vacuum / air into the medium) **Textbook: Discover Physics, 5th ed., p. 210 (Ch 12 Light, Refractive Index)** > *"The refractive index n of a medium is defined as the ratio of the speed of light in a vacuum to the speed of light in the medium."*	1
10(c)(ii)	speed in the glass $v = 3.0 \times 10^8 / 1.5 = 2.0 \times 10^8$ m/s; time = distance / speed = $0.30 / (2.0 \times 10^8)$ = **1.5×10^{-9} s** (answer with working) **Accept:** correct answer with working. Not accepted: 1.0×10^{-9} s (uses the speed in a vacuum)	1

Section A – Question 11 [4]

Part	Answer and mark points	Marks
11(a)	• **C** arrow in the direction from the positive terminal of the battery round the circuit: clockwise in Fig. 11.1 (up the left wire, across the top, down the right wire to the element) (1) • **E** arrow in the opposite direction (anticlockwise): from the negative terminal of the battery (1) **Accept:** both arrows on the right-hand wire (the wire between the switch and the element); C downwards, E upwards **Textbook: Discover Physics, 5th ed., p. 229 (Ch 13 Electric Charge and Current of Electricity, Conventional Current and Electron Flow)** > *"Electron flow is opposite in direction to conventional current."* **Textbook: Discover Physics, 5th ed., p. 229 (Ch 13 Electric Charge and Current of Electricity, Conventional Current and Electron Flow)** > *"The flow of electrons from the negative terminal of the battery to the positive terminal is opposite to the conventional current."*	2
11(b)(i)	the ratio of the potential difference across it to the current through it (resistance = p.d. / current) **Textbook: Discover Physics, 5th ed., p. 237 (Ch 13 Electric Charge and Current of Electricity, Resistance)** > *"The resistance R of a component is the ratio of the potential difference V across it to the current I flowing through it."*	1
11(b)(ii)	$R = V / I = 12 / 5.0 = 2.4\ \Omega$; new current = 14 / 2.4 = **5.8 A** (answer with working; 5.83 A accepted) **Accept:** ecf for a wrong resistance. Not accepted: 14 / 5.0 = 2.8 A (resistance not found first)	1

Section A – Question 12 [4]

Part	Answer and mark points	Marks
12(a)	• the current from the battery equals the sum of the currents in the branches: 6.0 = 2.5 + 1.5 + *I* (1) • *I* = **2.0 A** (1) **Textbook: Discover Physics, 5th ed., p. 255 (Ch 14 D.C. Circuits, Parallel Circuits)** > *"In a parallel circuit, the total current flowing into or out of the parallel branches is equal to the sum of the individual currents in each parallel branch."*	2
12(b)	• **12 V** (the same as before) (1) • each branch is connected directly across the battery, so the p.d. across every parallel branch is the same as the p.d. of the battery, whatever happens in the other branches; so L_1 still has 12 V across it and A_1 still reads 2.5 A (1) **Accept:** the p.d. across each branch of a parallel circuit is the same (equal to 12 V) **Textbook: Discover Physics, 5th ed., p. 256 (Ch 14 D.C. Circuits, Parallel Circuits)** > *"In a parallel circuit, the p.d. across the parallel branches is the same."*	2

Section A – Question 13 [3]

Part	Answer and mark points	Marks
13(a)	• nail A is made of a magnetic material (steel) and is touching a strong magnet, so it becomes magnetised by induction: its upper end, next to the N pole, becomes a S pole (1) • the lower end of nail A is a N pole; this magnetises nail B (induces a S pole in its upper end) and unlike poles attract, so nail B is attracted to nail A (1) **Accept:** the end of nail A nearest the magnet becomes the opposite pole; the other end becomes a N pole **Textbook: Discover Physics, 5th ed., p. 291 (Ch 16 Magnetism and Electromagnetism, Induced Magnetism)** > *"Induction, or induced magnetism, can take place when a magnetic material is placed close to a strong magnet or within a current-carrying solenoid."* **Textbook: Discover Physics, 5th ed., p. 288 (Ch 16 Magnetism and Electromagnetism, Properties of Magnets)** > *"Like magnetic poles repel and unlike magnetic poles attract."*	2
13(b)	at least three smooth lines leaving each N pole with arrows pointing away from the pole; the lines from the two poles bend away from each other and never join or cross, leaving a gap (neutral point) midway between the poles (all of these needed) (1) **Accept:** lines must touch the poles; arrows in the right direction. Not accepted: lines joining the two poles; lines that cross **Textbook: Discover Physics, 5th ed., p. 300 (Ch 16 Magnetism and Electromagnetism, Magnetic Field Patterns)** > *"Conversely, when two like poles are placed next to each other, the field lines move away from each other (Figure 16.33)."* **Textbook: Discover Physics, 5th ed., p. 301 (Ch 16 Magnetism and Electromagnetism, Magnetic Field Patterns)** > *"The direction of the magnetic field is given by the arrow."*	1

Section A – Question 14 [3]

Part	Answer and mark points	Marks
14(a)	• random: the counts are different in each interval (not a steady number), because it cannot be predicted when a particular nucleus will decay or how many will decay in a given time (1) • spontaneous: the nucleus decays by itself (emitting radiation and losing energy); it cannot be made to decay by heating, cooling, chemical means or any other method (1) **Accept:** an unstable nucleus loses energy by emitting radiation when it decays **Textbook: Discover Physics, 5th ed., p. 323 (Ch 17 Radioactivity, Nuclear Decay)** > *"The direction of the emissions and the time between emissions cannot be predicted."* **Textbook: Discover Physics, 5th ed., p. 323 (Ch 17 Radioactivity, Nuclear Decay)** > *"In other words, it is not possible: to make the radioactive nucleus emit radiation by heating, cooling, chemical means or any other method;"* **Textbook: Discover Physics, 5th ed., p. 323 (Ch 17 Radioactivity, Nuclear Decay)** > *"Nuclear decay is a random process by which an unstable atomic nucleus loses its energy by emission of electromagnetic radiation or particle(s)."*	2
14(b)	two protons and two neutrons; protons are positively charged and neutrons carry no charge, so the particle has a positive charge (both parts needed) **Accept:** a helium nucleus; charge +2 **Textbook: Discover Physics, 5th ed., p. 324 (Ch 17 Radioactivity, Three Types of Nuclear Emission)** > *"An α-particle consists of two protons and two neutrons tightly bound together."* **Textbook: Discover Physics, 5th ed., p. 319 (Ch 17 Radioactivity, The Atom)** > *"A proton is positively charged."* **Textbook: Discover Physics, 5th ed., p. 319 (Ch 17 Radioactivity, The Atom)** > *"A neutron does not carry any charge."*	1

Section B – Question 15 [10]

Part	Answer and mark points	Marks
15(a)	• the brown (live) wire and the blue (neutral) wire are connected to the wrong terminals: the fuse is in the neutral wire; it should be connected to the live (brown) wire (1) • if the fuse melts (or the switch is opened) the pump is still connected to the live wire, so the pump stays at a high voltage and can give an electric shock (the fuse cannot make the pump safe) (1) **Accept:** the live wire should be brown and go to terminal L (the fuse); neutral blue to N. Earth wire (green and yellow) is correct **Textbook: Discover Physics, 5th ed., p. 280 (Ch 15 Practical Electricity, Wiring in a Mains Plug)** > *"The live wire is usually brown."* **Textbook: Discover Physics, 5th ed., p. 280 (Ch 15 Practical Electricity, Wiring in a Mains Plug)** > *"The neutral wire is blue and is kept at zero voltage."* **Textbook: Discover Physics, 5th ed., p. 281 (Ch 15 Practical Electricity, Wiring in a Mains Plug)** > *"Switches and safety features such as fuses and circuit breakers have to be connected to the live wire in order to break or complete a circuit."* **Textbook: Discover Physics, 5th ed., p. 281 (Ch 15 Practical Electricity, Wiring in a Mains Plug)** > *"Consider the case in Figure 15.19 where the switch is connected to the neutral wire instead. Then the appliance becomes "live" and can create an electric shock when a person touches it even when the switch is open."*	2

15(b)(i)	• a large current flows from the live wire through the metal casing and the earth wire (which has very little resistance) to the ground (1) • the large current makes the fuse melt (blow), which disconnects the live wire, so the casing is not left at a high potential and the user does not get an electric shock (1) **Accept:** large current melts the fuse, cutting off the supply. Not accepted: "the earth wire takes the current away" with no mention of the fuse / the supply being cut off (1 mark at most) **Textbook: Discover Physics, 5th ed., p. 279 (Ch 15 Practical Electricity, Earthing the Metal Casing)** > *"An earthed metal casing is a metal housing that encloses the electrical parts of an appliance and is connected to the earth, keeping the user safe in the event of an electrical fault. The live current passing through the earth metal casing flows to the ground. As Earth wire has very little resistance, it is likely that the fuse will be blown. This prevents further current flow."*	2
15(b)(ii)	no, I do not agree (1) because the drill has double insulation: two layers of insulation enclose all the exposed metalwork and live parts, so the user cannot touch a live part even if a fault occurs (disagreement and reason both needed) **Textbook: Discover Physics, 5th ed., p. 280 (Ch 15 Practical Electricity, Double Insulation)** > *"Double insulation, as the name suggests, has two layers of insulation to enclose all exposed metalwork and "live" parts."*	1
15(c)(i)	QR: the graph is horizontal (zero gradient): the distance does not change; RS: the graph is a curve whose gradient (slope) gets steeper, so the speed increases (both needed) **Textbook: Discover Physics, 5th ed., p. 27 (Ch 2 Kinematics, 2.2 Distance–Time Graphs)** > *"The graph has zero gradient."* **Textbook: Discover Physics, 5th ed., p. 28 (Ch 2 Kinematics, 2.2 Distance–Time Graphs)** > *"The graph has an increasing gradient. The speed of the car increases."*	1
15(c)(ii)	• PQ (straight line, constant gradient): speed = gradient = 160 / 20 = **8.0 m/s** (1) • 8.0 m/s = 8.0 × 3.6 = 28.8 km/h (or the limit 20 km/h = 5.6 m/s), which is more than the limit, so the driver did **not** keep to the speed limit (1) **Accept:** conclusion must follow from the student's own speed (ecf). Not accepted: 8.0 > 20 with no conversion of units **Textbook: Discover Physics, 5th ed., p. 27 (Ch 2 Kinematics, 2.2 Distance–Time Graphs)** > *"The graph has a constant gradient."* **Textbook: Discover Physics, 5th ed., p. 27 (Ch 2 Kinematics, 2.2 Distance–Time Graphs)** > *"The gradient of a distance–time graph of an object gives the speed of the object."*	2
15(d)(i)	acceleration of free fall = 10 m/s^2, so v = 10 × 0.60 = **6.0 m/s** (9.8 m/s^2 gives 5.9 m/s, accepted) **Textbook: Discover Physics, 5th ed., p. 38 (Ch 2 Kinematics, 2.3 Acceleration of Free Fall)** > *"Acceleration due to gravity g is a constant. For objects close to Earth's surface, the value of g is generally taken to be 9.8 m/s². For simplicity in calculations, we take this value to be 10 m/s² throughout this book, unless otherwise stated."*	1
15(d)(ii)	**12 m/s** (1) because the acceleration is constant, so the speed increases by 10 m/s every second / the speed doubles when the time doubles (answer and reason both needed) **Textbook: Discover Physics, 5th ed., p. 38 (Ch 2 Kinematics, 2.3 Acceleration of Free Fall)** > *"Acceleration due to gravity g is a constant."*	1

Section B – Question 16 [10]

Part	Answer and mark points	Marks
16(a)(i)	difference = 68 − 38 = **30 °C** (accept 29 to 31 °C) and energy is transferred from the engine block (higher temperature) to the water (lower temperature) (both needed) **Textbook: Discover Physics, 5th ed., p. 134 (Ch 8 Thermal Processes, 8.1 What Is Thermal Equilibrium?)** > *"Energy is transferred from a region of higher temperature (hotter object) to a region of lower temperature (cooler object) until both regions have the same temperature."*	1
16(a)(ii)	after **16 min** (accept 15 to 17 min) the two temperatures are the same (50 °C), a state of thermal equilibrium, so there is no energy transfer (time and reason both needed) **Textbook: Discover Physics, 5th ed., p. 134 (Ch 8 Thermal Processes, 8.1 What Is Thermal Equilibrium?)** > *"The two regions are said to be in a state of thermal equilibrium."*	1
16(b)(i)	• conduction: energy is conducted through the copper (a good thermal conductor) wall of the pipe to the air touching it (1) • convection: the heated air expands, becomes less dense and rises, while cooler, denser air sinks to take its place, so a convection current carries energy across the carriage (1) **Accept:** each named process needs its explanation for the mark. Radiation may replace convection: the hot pipe emits infrared radiation which travels across the carriage and is absorbed by the passenger **Textbook: Discover Physics, 5th ed., p. 137 (Ch 8 Thermal Processes, Conduction in Solids)** > *"In general, metals are better thermal conductors than non-metals."* **Textbook: Discover Physics, 5th ed., p. 139 (Ch 8 Thermal Processes, Convection)** > *"The warm liquid, being less dense than its surroundings, will rise. The cold liquid, being denser, will sink."*	2
16(b)(ii)	a larger surface area emits (infrared) radiation at a higher rate, so energy leaves the oil cooler faster (1) (larger area and higher rate both needed) **Accept:** a larger surface area also absorbs radiation at a higher rate, but the cooler is hotter than its surroundings so there is a net loss **Textbook: Discover Physics, 5th ed., p. 141 (Ch 8 Thermal Processes, Surface Area)** > *"A larger surface area will emit energy at a higher rate via radiation."*	1
16(c)(i)	• **P** and **Q** are magnets because repulsion occurs only between two magnets (like poles repel) (1) • **R** is not a magnet: it is attracted by both ends of P (a magnet would repel one of the ends); it is an unmagnetised magnetic material, which a magnet attracts (1) **Accept:** R is unmagnetised steel / iron **Textbook: Discover Physics, 5th ed., p. 289 (Ch 16 Magnetism and Electromagnetism, Properties of Magnets)** > *"Attraction can also take place between a magnet and an object that is made of an unmagnetised magnetic material. However, repulsion can only occur between two magnets."* **Textbook: Discover Physics, 5th ed., p. 290 (Ch 16 Magnetism and Electromagnetism, Distinguishing Magnets and Unmagnetised Magnetic Materials)** > *"The bar is a magnet if and only if it is repelled by one of the poles of the magnet."*	2
16(c)(ii)	most filings stick at the ends (poles) of the bar (1): the magnetic force is strongest at the poles (both parts needed) **Textbook: Discover Physics, 5th ed., p. 288 (Ch 16 Magnetism and Electromagnetism, Properties of Magnets)** > *"When iron filings are sprinkled onto a bar magnet, most of the iron filings are attracted to the two ends of the magnet"*	1

16(d)	• a (pivoted / free-to-move) copper wire is placed between the poles of a strong magnet and connected to a d.c. supply (cell or battery and switch); when the switch is closed the wire moves (swings) (set-up and observation both needed) (1) • **upwards** (no change) because reversing the current reverses the force and reversing the poles (the magnetic field) also reverses the force, so the two reversals cancel out (answer and reason both needed) (1) **Accept:** the wire moves in the opposite direction if only one of the current or the magnet is reversed (not asked) **Textbook: Discover Physics, 5th ed., p. 308 (Ch 16 Magnetism and Electromagnetism, Force on a Current-carrying Conductor)** > *"This effect can be demonstrated using the set-up in Figure 16.50."* **Textbook: Discover Physics, 5th ed., p. 309 (Ch 16 Magnetism and Electromagnetism, Force on a Current-carrying Conductor)** > *"When the switch is closed, the copper wire frame immediately swings outwards (Figure 16.51(a))."* **Textbook: Discover Physics, 5th ed., p. 309 (Ch 16 Magnetism and Electromagnetism, Force on a Current-carrying Conductor)** > *"If the connection of the terminals is reversed, the copper wire frame swings in the opposite direction. The copper wire frame will also swing in the opposite direction if the polarity of the magnet is reversed."* **Textbook: Discover Physics, 5th ed., p. 309 (Ch 16 Magnetism and Electromagnetism, Force on a Current-carrying Conductor)** > *"Reversing the direction of current induces a swing in the opposite direction."* **Textbook: Discover Physics, 5th ed., p. 309 (Ch 16 Magnetism and Electromagnetism, Force on a Current-carrying Conductor)** > *"Reversing the polarity of the magnet also reverses the direction of the swing."*	2