SCIENCE (PHYSICS) – Paper 2 Physics (set 2.4) – 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 unit (of mass, e.g. g / grams) **Accept:** a named unit such as g, kg **Textbook: Discover Physics, 5th ed., p. 3 (Ch 1 Physical Quantities, Units and Measurements)** > *"A physical quantity is a quantity that can be measured. It consists of a numerical magnitude and a unit."*	1
1(b)	• distance in the first part = speed × time = 0.40 × 2.0 = 0.80 m; total distance = 0.80 + 1.00 = 1.80 m; total time = 2.0 + 3.0 + 4.0 = 9.0 s, the time when the buggy is stopped included (1) • average speed = total distance / total time = 1.80 / 9.0 = **0.20 m/s** (1) • **Not accepted:** 0.30 m/s (the 3.0 s stop left out of the total time); the mean of the three speeds; 1.00 / 4.0 on its own **Accept:** 0.20 m s^{-1}; 20 cm/s (with unit); 1 mark for total distance and total time with an arithmetic slip in the division	2

Section A – Question 2 [3]

Part	Answer and mark points	Marks
2(a)	• the acceleration decreases (to zero) as the graph becomes less steep / the gradient decreases, **and** the acceleration is zero from 1.0 s to 3.0 s because the graph is horizontal / the speed is constant (both needed, 1) **Accept:** acceleration is not constant; becomes smaller and smaller; 0 m/s^2 **Textbook: Discover Physics, 5th ed., p. 26 (Ch 2 Kinematics, 2.1)** > *"An object undergoes non-uniform acceleration if the change in its velocity for every unit of time is not the same (Table 2.4)."*	1
2(b)	• distance = area under the graph, split into three sections (1): 2.0 s to 3.0 s: 12 × 1.0 = 12 cm; 3.0 s to 4.0 s: ½ × (12 + 6) × 1.0 = 9 cm; 4.0 s to 5.0 s: 6 × 1.0 = 6 cm • total = 27 cm = **0.27 m** (converted to metres, 1) **Accept:** the first mark for any two of the three areas correctly found and added; **27 cm** scores 1 mark only (not converted to metres)	2

Section A – Question 3 [4]

Part	Answer and mark points	Marks
3(a)	• $W = mg$, so $m = W / g$ = 2.8 / 10 (1) • **0.28 kg** (1) **Accept:** 280 g (with unit)	2
3(b)	• volume = 95 − 60 = 35 cm^3; mass = 280 g; density = mass / volume = 280 / 35 (1) • **8.0 g/cm^3** (1) **Accept:** 8000 kg/m^3; a final reading of 94 to 96 cm^3 (7.8 to 8.2 g/cm^3); ecf for a wrong mass from (a) provided the unit is converted correctly	2

Section A – Question 4 [6]

Part	Answer and mark points	Marks
4(a)	• force (acting normally / at right angles to the surface) (1) • per unit area (1) **Accept:** pressure = force / area, with the symbols or words defined **Textbook: Discover Physics, 5th ed., p. 57 (Ch 3 Force and Pressure, 3.4)** *"Pressure is the force acting per unit area."*	2
4(b)	• resultant force = 1.8 − 0.60 = 1.2 N (1) • $a = F / m$ = 1.2 / 0.40 = **3.0 m/s^2** (1) **Accept:** a method mark for 1.2 / 0.40 or 1.8 / 0.40 with the resultant force identified	2
4(c)	• friction acts opposite to the motion / between the block and the bench (1) • friction is then the (only horizontal) force / resultant force, so the block decelerates until it stops (1) **Accept:** energy of the block is transferred to thermal energy by friction (as an extra point, not instead) **Textbook: Discover Physics, 5th ed., p. 66 (Ch 4 Dynamics, 4.1)** *"If the applied force F is now removed while the book is still in motion (Figure 4.6(b)), friction is the resultant force. The resultant force causes the book to decelerate and eventually stop."* **Textbook: Discover Physics, 5th ed., p. 74 (Ch 4 Dynamics, 4.3)** *"Friction is the contact force that opposes or tends to oppose motion between surfaces in contact."*	2

Section A – Question 5 [4]

Part	Answer and mark points	Marks
5(a)	the turning effect of the force about the pivot **Accept:** force × perpendicular distance from the pivot (as a description of turning effect) **Textbook: Discover Physics, 5th ed., p. 82 (Ch 5 Turning Effects of Forces, 5.1)** *"The turning effect of a force is called its moment."*	1
5(b)	• perpendicular distance from the pivot = 25 cm = 0.25 m, read from Fig. 5.1 (1) • moment = force × perpendicular distance from the pivot = 6.0 × 0.25 = **1.5 N m** (1) • **Not accepted:** 150 N m (distance not converted to metres) **Accept:** 1.5 N m anticlockwise / clockwise not required	2
5(c)	$E = mgh$, so $h = E / mg$ = 0.36 / (0.020 × 10) = **1.8 m** (1) **Accept:** 180 cm (with unit)	1

Section A – Question 6 [4]

Part	Answer and mark points	Marks
6(a)	• the (average) kinetic energy of the water particles increases / the particles move faster (1) • temperature rises with the average kinetic energy of the particles (1) **Accept:** particles vibrate / move faster as energy is transferred to them **Textbook: Discover Physics, 5th ed., p. 129 (Ch 7 Kinetic Particle Model of Matter, 7.2)** *"It is important to remember that temperature rises with the average kinetic energy of the particles in the body and vice versa."*	2

6(b)	• the temperature stays constant at 100 °C (the boiling point), so the average kinetic energy of the particles is not changing (1) • the energy transferred to the water does work against the attractive forces between the particles: their average separation increases as the liquid changes to a gas, so their potential energy increases (1) • **Not accepted:** 'the water cannot get any hotter'; 'the energy stops being absorbed' **Accept:** the particles move further apart / break away from each other **Textbook: Discover Physics, 5th ed., p. 129 (Ch 7, 7.2)** *"During melting and boiling, energy transferred to the substance results in work done against the attractive intermolecular forces. The average separation of the particles increases and so the potential energy of the particles increases."* **Textbook: Discover Physics, 5th ed., p. 129 (Ch 7, 7.2)** *"However, during these processes of changing states, the average kinetic energy of the particles remains constant. Hence, the temperature stays constant."*	2

Section A – Question 7 [6]

Part	Answer and mark points	Marks
7(a)	• the water above the flame is heated, expands and becomes less dense (than the surrounding water), so it rises (1) • cooler, denser water sinks (on the right-hand side) and moves along the bottom to take its place, so the water circulates clockwise (1) • **Not accepted:** 'hot water rises because heat rises' with no mention of density **Accept:** the warm water carries the dye with it; up on the left and down on the right **Textbook: Discover Physics, 5th ed., p. 139 (Ch 8 Thermal Processes, 8.2)** *"When a liquid is heated, it expands and increases in volume. As volume increases, density decreases. The warm liquid, being less dense than its surroundings, will rise. The cold liquid, being denser, will sink. This difference in density results in convection currents (Figure 8.9)."*	2
7(b)(i)	by radiation / infrared (electromagnetic) waves, which do not need a (material) medium **Accept:** electromagnetic waves travel through a vacuum **Textbook: Discover Physics, 5th ed., p. 140 (Ch 8, 8.2)** *"Radiation is the process of energy transfer by electromagnetic waves. It does not require a medium."*	1
7(b)(ii)	• the dull black surface is a better absorber of radiation than the shiny silver surface (so absorbs energy at a faster rate) • **Not accepted:** 'black attracts heat'; 'black is hotter' **Textbook: Discover Physics, 5th ed., p. 142 (Ch 8, 8.2)** *"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
7(c)	• infra-red: remote controllers / intruder alarms / thermal imaging / cooking or heating (1) • ultraviolet: sterilising or disinfecting water / checking bank notes / sunbeds (1) **Accept:** any other correct typical use **Textbook: Discover Physics, 5th ed., p. 190 (Ch 11 Electromagnetic Waves, 11.2)** *"Devices such as the television and air conditioners can be remotely turned on or off using an infrared remote controller."* **Textbook: Discover Physics, 5th ed., p. 192 (Ch 11, 11.2)** *"In Singapore's water treatment plants, UV light plays an important role in disinfection and sterilisation by killing bacteria and viruses."*	2

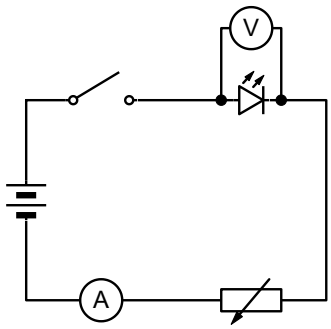
Section A – Question 8 [4]

Part	Answer and mark points	Marks
8(a)	• a disturbance / vibration from the dipper travels outwards across the water, transferring energy (but not the water itself) (1) • a wavefront is an (imaginary) line joining all adjacent points that are moving in step / in phase, e.g. one circular crest (1) • **Not accepted:** 'the water moves outwards with the wave' **Textbook: Discover Physics, 5th ed., p. 156 (Ch 9 General Wave Properties I, 9.1)** > *"A wave is a disturbance that propagates through space, transferring energy with it but not matter."* **Textbook: Discover Physics, 5th ed., p. 157 (Ch 9, 9.1)** > *"The imaginary line that joins all adjacent points on the wave that are moving in step is called a wavefront."*	2
8(b)	• the sound pulse is reflected by the wall and returns to the sensor as an echo (1) • the time is for the journey to the wall and back, so distance = (speed of sound × time) / 2 = 340 × 0.080 / 2 = **13.6 m** (1) • **Not accepted:** 27.2 m (the time is not halved) **Accept:** distance = speed × time for a to-and-fro journey, halved; 340 × 0.040 = 13.6 m; 14 m **Textbook: Discover Physics, 5th ed., p. 176 (Ch 10 General Wave Properties II, Sound, 10.3)** > *"The reflected sound is called an echo."* **Textbook: Discover Physics, 5th ed., p. 177 (Ch 10, 10.3)** > *"With the speed of sound, computer-controlled sound emitter and sound sensor, the distance from the emitter to the reflecting surface can be easily calculated."*	2

Section A – Question 9 [4]

Part	Answer and mark points	Marks
9(a)	• current is the rate of flow of (electric) charge (1) • measured in amperes (A) = coulombs per second, so 0.50 C (coulomb) of charge flows past a point (in the circuit) every second (1) **Accept:** 0.50 coulomb per second **Textbook: Discover Physics, 5th ed., p. 228 (Ch 13 Electric Charge and Current of Electricity, 13.2)** > *"Electric current is the rate of flow of electric charge."* **Textbook: Discover Physics, 5th ed., p. 228 (Ch 13, 13.2)** > *"The SI unit for current is ampere (A) or coulomb (C) per second (s)."*	2
9(b)	• the electromotive force (e.m.f.) of the battery pack (1) • measured in volts (V) (1) • **Not accepted:** current; charge; energy; power; ampere or coulomb as the unit **Accept:** voltage (of the source) for the quantity; volt, volts or V for the unit **Textbook: Discover Physics, 5th ed., p. 232 (Ch 13, 13.3)** > *"The electromotive force (e.m.f) of an electrical source is the work done by the source in driving a unit charge around a complete circuit."* **Textbook: Discover Physics, 5th ed., p. 232 (Ch 13, 13.3)** > *"The SI unit of e.m.f. is volt (V). Its SI units may also be written as J/C, but it is uncommon to do so."*	2

Section A – Question 10 [4]

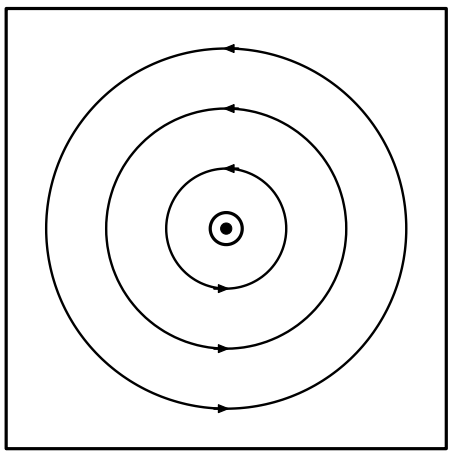
Part	Answer and mark points	Marks
10(a)	series loop containing cell/battery, switch, LED, variable resistor and ammeter, all with correct symbols (1) voltmeter connected in parallel across the LED only (1)  one possible answer **Accept:** components in any order; LED polarity is not penalised	2
10(b)	• 12 mA, read from Table 10.1 at 2.0 V for the current in the LED (1) • the current at every point in a series circuit is the same, so both ammeters read the same (1) • **Not accepted:** 2 mA or 30 mA (wrong row of the table); a reading with no reason scores 1 mark only **Accept:** 0.012 A **Textbook: Discover Physics, 5th ed., p. 250 (Ch 14 D.C. Circuits, 14.1)** *"In a series circuit, the current at every point is the same."*	2

Section A – Question 11 [5]

Part	Answer and mark points	Marks
11(a)(i)	exposed live wire(s) can give an electric shock when touched (accept: short circuit / overheating and fire) **Textbook: Discover Physics, 5th ed., p. 274 (Ch 15 Practical Electricity, 15.2)** *"Wires are usually covered with insulating materials to prevent electric shocks (Figure 15.8(a))."*	1
11(a)(ii)	water conducts electricity, so a current may pass through the user's body, giving an electric shock **Textbook: Discover Physics, 5th ed., p. 275 (Ch 15, 15.2)** *"Water usually contains charged ions and impurities that make it a good conductor of electricity. Hence, many electrical accidents occur in damp environments."*	1
11(b)	• neutral: the wire at (about) zero voltage that completes the path / circuit for the current (1) • earth: a safety wire that connects the metal case of the appliance to the earth (1) • **Not accepted:** neutral = 'no current' **Textbook: Discover Physics, 5th ed., p. 280 (Ch 15, 15.2)** *"The neutral wire is blue and is kept at zero voltage. It completes the path for current to flow through appliances in the electrical circuit."* **Textbook: Discover Physics, 5th ed., p. 280 (Ch 15, 15.2)** *"The earth wire is yellow and green. It is a safety wire that is needed to earth appliances with a metal case."*	2

11(c)	• with the switch in the neutral wire, the heater and the exposed wires inside the water bath are still connected to the live (high-voltage) wire when the switch is open, so touching them can still give an electric shock (a switch or fuse in the live wire disconnects the appliance from the live supply) • **Not accepted:** 'the live wire carries the current' on its own; 'the circuit is still complete' (it is broken when the switch is open) **Textbook: Discover Physics, 5th ed., p. 281 (Ch 15, 15.2)** *"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."*	1

Section A – Question 12 [5]

Part	Answer and mark points	Marks
12(a)	• property: a temporary magnet (iron) is easily magnetised and demagnetised / loses its magnetism when the current or field is removed; a permanent magnet (steel) keeps its magnetism (1) • use: temporary magnets in electromagnets (e.g. lifting scrap metal); permanent magnets e.g. compass needles / recording media in hard disk drives (1) **Accept:** any correct use of each **Textbook: Discover Physics, 5th ed., p. 294 (Ch 16 Magnetism and Electromagnetism, 16.1)** *"Temporary magnets retain their magnetism in the presence of an electric current or a permanent magnetic field."* **Textbook: Discover Physics, 5th ed., p. 294 (Ch 16, 16.1)** *"Permanent magnets do not require the presence of an electric current or a permanent magnetic field to retain their magnetism."*	2
12(b)	place the compass at the point; the direction in which the north (N) end of the needle points is the direction of the field **Textbook: Discover Physics, 5th ed., p. 298 (Ch 16, 16.2)** *"The direction of the field lines is indicated by the direction of the plotting compass needle (Figure 16.28)."*	1
12(c)(i)	two concentric circles centred on the wire, with arrows showing the field direction anticlockwise (1)  one possible answer **Accept:** more than two circles; arrows anywhere on a circle; the lines must be centred on the wire and the direction anticlockwise **Textbook: Discover Physics, 5th ed., p. 304 (Ch 16, 16.3)** *"The directions of the needles on the compasses follow the right-hand grip rule. If we grip the conductor with our thumb pointing in the direction of the conventional current, the curl of the fingers shows the direction of the magnetic field (Figure 16.41)."*	1

12(c)(ii)	the magnetic field becomes stronger **and** its direction is reversed (now clockwise) (both needed, 1) **Textbook: Discover Physics, 5th ed., p. 305 (Ch 16, 16.3)** *"Changing the magnitude of the current changes the strength of magnetic field. The strength of magnetic field increases when the current is increased (Figure 16.42)."* **Textbook: Discover Physics, 5th ed., p. 305 (Ch 16, 16.3)** *"Changing the direction of the current changes the direction of the magnetic field."*	1

Section A – Question 13 [3]

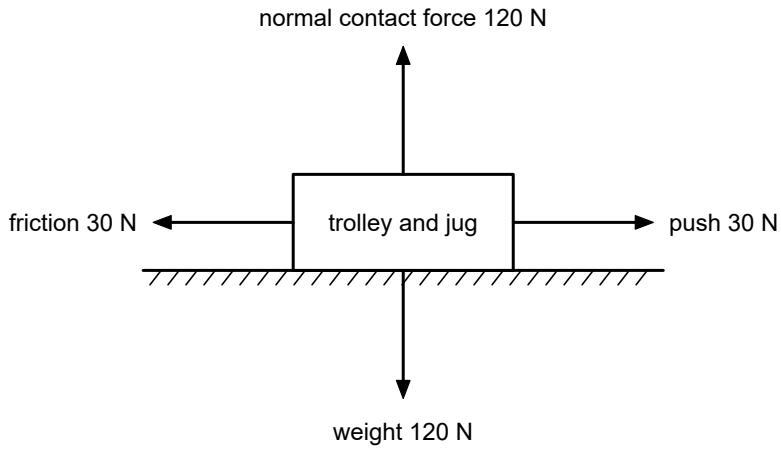
Part	Answer and mark points	Marks
13(a)	P and R (same proton number, different nucleon numbers) **and** P has 131 − 53 = 78 neutrons (R has 74) (both needed, 1) **Textbook: Discover Physics, 5th ed., p. 322 (Ch 17 Radioactivity, 17.1)** *"Isotopes are atoms of the same element that have the same numbers of protons but different numbers of neutrons."*	1
13(b)(i)	background radiation, e.g. radon gas in the air / rocks / cosmic rays / food and drink / medical X-rays / building materials **Textbook: Discover Physics, 5th ed., p. 326 (Ch 17, 17.2)** *"Background radiation refers to nuclear radiation in an environment where no radioactive source has been deliberately introduced."*	1
13(b)(ii)	background count rate = 36 / 10 = 3.6 counts/min; count rate with the sample = 93 / 5.0 = 18.6 counts/min; background radiation is also detected, so subtract it: 18.6 − 3.6 = **15 counts/min** (all three steps shown, 1) **Accept:** 0.25 counts/s. **Not accepted:** 18.6 counts/min (background not subtracted); (93 − 36) / 10 = 5.7 (the two counting times are different); a bare 15 with no working **Textbook: Discover Physics, 5th ed., p. 327 (Ch 17, 17.2)** *"When carrying out any measurements with radioactive sources, we should first measure the background radiation. Subtract this background count rate from the measurements to obtain the corrected count rate for the radioactive source."*	1

Section B – Question 14 [10]

Part	Answer and mark points	Marks
14(a)	• the lens refracts the rays (at both surfaces) / bends the rays towards the principal axis (1) • the rays converge (to a point) on the principal axis: they meet at the principal focus, one focal length (15 cm) from the lens (1) • the block should be held at the principal focus, 15 cm from the lens, because all the energy of the beam is concentrated on the block there; at 40 cm the rays have crossed and are spreading out again, so the block receives less energy each second (1) • **Not accepted:** the word 'focuses' alone for the first mark; 'nearer the lens is hotter' **Accept:** the answer to the decision may be given first; 15 cm behind the lens (on the side away from the Sun) **Textbook: Discover Physics, 5th ed., p. 214 (Ch 12 Light, 12.3)** > *"Its shape allows a beam of parallel rays passing through it to be brought to a single focal point."* **Textbook: Discover Physics, 5th ed., p. 215 (Ch 12, 12.3)** > *"Notice that refraction happens upon entry and exit of each section. The lens is designed in such a way that all emerging rays converge at a point."* **Textbook: Discover Physics, 5th ed., p. 216 (Ch 12, 12.3 (principal focal point F))** > *"The point on the principal axis where all rays parallel to the principal axis meet after passing through the lens"*	3
14(b)(i)	sin 40° / sin 25° = **1.52** and sin 60° / sin 35° = **1.51** (both correct, 1) **Accept:** 1.52 and 1.51 only when placed in the correct rows (1.5 is not accepted: two decimal places were asked for)	1
14(b)(ii)	sin i / sin r is constant (about 1.5): sin r = sin 50° / 1.52 = 0.504, so r = **30°** **Accept:** 30° or 31° (from a constant of 1.50 to 1.52); ecf from a different constant taken from the table or from part (i)	1
14(c)	• force = total weight = mg = (0.45 + 0.35) × 10 = 8.0 N (1) • distance moved in the direction of the force = 0.90 − 0.15 = 0.75 m (1) • work done = force × distance moved in the direction of the force = 8.0 × 0.75 = **6.0 J** (1) **Accept:** ecf from a wrong force or distance; 0.80 × 10 × 0.90 = 7.2 J (height not subtracted) scores the first and third marks only **Textbook: Discover Physics, 5th ed., p. 113 (Ch 6 Energy, 6.2)** > *"Work done by a constant force on an object is the product of the force and the distance moved by the object in the direction of the force."*	3
14(d)(i)	internal (thermal) energy store **Accept:** internal energy	1
14(d)(ii)	• the energy transferred to the block by radiation each second equals the energy transferred (by heating) from the hotter block to its cooler surroundings each second, so the energy in its internal store, and its temperature, stay constant • **Not accepted:** 'the block cannot absorb any more energy'; 'the block is full of heat'	1

Section B – Question 15 [10]

Part	Answer and mark points	Marks
15(a)	• average fall = (46 − 30) / 20 = **0.80 °C per minute** (1) • energy is transferred (by heating) from the hot water (higher temperature) to the cooler air (lower temperature) until both are at the same temperature (thermal equilibrium), so the water ends at 20 °C (both the description and 20 °C needed, 1) **Accept:** 0.8 °C/min; room temperature for 20 °C **Textbook: Discover Physics, 5th ed., p. 134 (Ch 8 Thermal Processes, 8.1)** > *"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. The two regions are said to be in a state of thermal equilibrium."*	2
15(b)(i)	bubble wrap traps air, which is a poor conductor, so energy loss by conduction is reduced (B falls by 16 °C less than A) **Textbook: Discover Physics, 5th ed., p. 145 (Ch 8, 8.3)** > *"The trapped air in the thermal wear acts as an insulating layer and reduces the loss of body heat to the surroundings via conduction."*	1
15(b)(ii)	the lid stops warm air rising away from the surface, so energy loss by convection is reduced (C falls by 11 °C less than B) **Accept:** stops convection currents carrying energy away	1
15(b)(iii)	• stand the jug on an insulating mat (e.g. wood, cork, plastic, polystyrene) because it is a poor thermal conductor (thermal insulator), so energy is transferred more slowly by conduction from the base of the jug to the bench (suggestion and reason both needed, 1) • **Not accepted:** a suggestion with no reason; a metal or 'thin' mat; a change that reduces loss by convection or radiation instead **Accept:** a thicker pad of bubble wrap under the base because trapped air is a poor conductor **Textbook: Discover Physics, 5th ed., p. 137 (Ch 8, 8.2)** > *"Materials that transfer energy slowly by conduction are poor thermal conductors. Poor thermal conductors are also known as thermal insulators."*	1

15(c)	• weight 120 N (down) and normal contact force 120 N (up), equal in length and labelled with sizes (1) • push 30 N (forward) and friction / air resistance 30 N (backward), equal in length and labelled with sizes (1)  one possible answer **Accept:** friction or air resistance (or both together) for the backward force; arrows to start on the trolley (or at its centre); 1 mark if all four forces are correct but lengths are unequal or sizes missing **Textbook: Discover Physics, 5th ed., p. 65 (Ch 4 Dynamics, 4.1)** *"Based on Newton's First Law of Motion, when the resultant force acting on a body is zero, a body is at rest or is moving at a constant velocity."*	2
15(d)(i)	the push (30 N) is equal and opposite to the friction (30 N), and weight and normal force are equal, so the forces are balanced / the resultant force is zero and the velocity does not change **Textbook: Discover Physics, 5th ed., p. 65 (Ch 4, 4.1)** *"Based on Newton's First Law of Motion, when the resultant force acting on a body is zero, a body is at rest or is moving at a constant velocity."*	1
15(d)(ii)	resultant force = 42 − 30 = 12 N forward, so the trolley accelerates (speeds up) in the direction of the push (both needed, 1) **Textbook: Discover Physics, 5th ed., p. 66 (Ch 4, 4.1)** *"When there is a resultant force acting on an object, the object will accelerate in the direction of the resultant force."*	1
15(d)(iii)	• 42 N, backwards (opposite to her push), acting on her hands (equal and opposite reaction; the size, direction and object all needed, 1) • **Not accepted:** 12 N; 30 N; friction; weight **Textbook: Discover Physics, 5th ed., p. 69 (Ch 4, 4.1)** *"Thus, for every action, there is an equal and opposite reaction."*	1