CAMBRIDGE IGCSE (0478)

Module J: Hardware and emerging tech

Workbooklet mark scheme · 7 parts · 148 marks

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MODULE J HARDWARE AND EMERGING TECH · J1

Input and output devices: mark scheme

21 marks · Cambridge 0478 syllabus 3.2.1 (what is meant by an input device and why it is required) and 3.2.2 (what is meant by an output device and why it is required)

How to use. One mark per creditworthy point up to the maximum shown. **/** separates alternative words; **//** separates alternative answers. Words in (brackets) are not needed for the mark. Credit any other valid answer that shows the same understanding.

QUESTION	ANSWER	MARKS	GUIDANCE
1(a) 0478 3.2.1	Any two from: (Hardware) used to enter / put data / instructions into a computer Captures data from the outside world // from the user Converts the data into a form the computer can process // into binary / digital data Required so the computer receives data / instructions to process // without input there is nothing to process Required so a user can interact with / control the computer Credit any other valid answer	**2**	max 2. A correct example alone (e.g. "a keyboard") is not enough. Do not credit "stores data" or "displays data".
1(b) 0478 3.2.2	Any two from: (Hardware) used to present / give out the results of processing (from a computer) In a form a person can see / hear // as a display / sound / printout Can cause a physical action // movement (e.g. an actuator) Required so the user can see / hear / use the results of processing Required so a computer can make something happen // control a device in the physical world Credit any other valid answer	**2**	max 2. A correct example alone (e.g. "a speaker") is not enough. Do not credit "stores data" or "puts data into the computer".
2(a) 0478 3.2.1, 3.2.2	3D scanner: Input device Actuator: Output device QR code scanner: Input device DLP projector: Output device Microphone: Input device	**5**	One mark per correct row. A row with both boxes ticked scores 0 for that row.
3(a) 0478 3.2.1 (touch screen)	Beams of light broken: infra-red Top layer pushed onto layer below: resistive Finger changes the electrical charge: capacitive	**3**	One mark per correct row. Accept IR for infra-red. Ignore spelling if the type is clear.
3(b) 0478 3.2.1 (touch screen)	Capacitive (touch screen) … it detects a touch by the change in electrical charge caused by a (bare) finger // a (thick) glove does not change the charge on the screen // a glove does not conduct / stops the finger's charge reaching the screen	**2**	Second mark depends on "capacitive". If resistive or infra-red is given, award 0. Do not accept "the glove is too thick to press the screen" or "gloves block the beams".

QUESTION	ANSWER	MARKS	GUIDANCE
4(a) 0478 3.2.2 (printers)	400 text-only leaflets: laser printer One high-quality colour photograph: inkjet printer Small plastic clip: 3D printer	**3**	One mark per correct row. Accept "laser", "inkjet", "3D".
5(a) 0478 3.2.1, 3.2.2	Mark in pairs: one mark for a suitable device, one mark for why it is required in this system. **Input** (max 2), any one pair from: QR code scanner // (digital) camera … … to read / capture the QR code on the plant label so the system can identify / look up the plant Touch screen … … so the customer can choose / search for the plant // select options Keyboard // microphone … … so the customer can type / say the name of the plant to look it up **Output** (max 2), any one pair from: (LCD / LED) screen // touch screen // monitor … … to display the care instructions so the customer can read them Speaker … … to read the care instructions aloud so the customer can hear them (Inkjet / laser) printer … … to print the care instructions so the customer can take them home Credit any other valid device with a matching reason	**4**	max 4. Each reason mark depends on a suitable device of the right kind. The reason must refer to the help point (e.g. the QR code, the plant, the care instructions); "to input data" or "to output data" alone is not enough. Accept "barcode scanner" only if the reason says it reads the QR code. Accept LCD / DLP projector with a display reason. Do not credit an output device given as the input device, or the reverse. If more than one device is given in a box, mark the first.

Total: 21 marks

MODULE J HARDWARE AND EMERGING TECH · J3

Sensors and what they measure: mark scheme

22 marks · Cambridge 0478 syllabus 3.2.3(a) (what is meant by a sensor and the purposes of sensors) and 3.2.3(b) (the data each sensor captures, when each is used, and selecting the most suitable sensor for a given context; sensors limited to acoustic, accelerometer, flow, gas, humidity, infra-red, level, light, magnetic field, moisture, pH, pressure, proximity, temperature)

How to use. One mark per creditworthy point up to the maximum shown. **/** separates alternative words; **//** separates alternative answers. Words in (brackets) are not needed for the mark. Credit any other valid answer that shows the same understanding. A sensor must be named by its type from the syllabus list; "motion sensor" is not precise enough and is not credited.

QUESTION	ANSWER	MARKS	GUIDANCE
1(a) 0478 3.2.3(a)	Any two from: An input device that measures / detects a physical property // quantity // by example (e.g. temperature, light, sound) of its surroundings / environment captures data and sends it to a computer / microprocessor (to be processed)	**2**	max 2. Do not accept "an output device" or "a device that controls / moves something" (that is an actuator).
1(b) 0478 3.2.3(a)	Any two from: To capture / collect data about the environment // to monitor conditions (e.g. temperature of a room) To take readings automatically // without a person needing to be present To take readings continuously // at regular intervals // over a long period To provide (input) data for a computer / microprocessor / automated system to process or act on // so a system can respond to changes To take readings in places that are dangerous / difficult for people to reach To take readings more accurately / more often than a person could	**2**	max 2. Credit any other valid purpose. Two answers that make the same point (e.g. "monitor temperature" and "monitor light") score 1.
2 0478 3.2.3(b)	One mark for each correct line: pH → How acidic or alkaline a substance is proximity → How near an object is to the sensor flow → The rate at which a liquid or gas moves through a pipe acoustic → The level of sound	**4**	A sensor with more than one line drawn from it scores 0 for that sensor. "The height of a liquid in a container" (level) is not used.
3 0478 3.2.3(b)	One mark for each row: Water dropped below a marked height: level (sensor) Water warm enough for tropical fish: temperature (sensor) Brightness of the lamps: light (sensor) Carbon dioxide in the air: gas (sensor)	**4**	Accept carbon dioxide / CO_2 sensor for gas. Do not credit pressure for row 1, infra-red for row 2 or humidity for row 4: the question asks for the most suitable sensor. If the same sensor is given in two rows, credit it only in the row where it is correct.

QUESTION	ANSWER	MARKS	GUIDANCE
4(a) 0478 3.2.3(b)	Accelerometer	**1**	Do not accept motion sensor, pressure or proximity.
4(b) 0478 3.2.3(b)	Any two from: It measures acceleration // changes in speed / direction of movement A drop / shake causes a sudden / large change in acceleration // movement that it detects / records It measures tilt / orientation // the angle of the box ... so it can detect that the box has been tipped over It detects the movement of the box itself // it needs nothing outside the box to detect a drop	**2**	max 2. If 4(a) is not an accelerometer, 4(b) scores 0. Do not accept "it detects movement" alone with no link to the drop, shake or tilt.
5 0478 3.2.3(b)	One mark for a suitable sensor: Magnetic field // proximity // infra-red (sensor) Then any two from, linked to the sensor named: **Magnetic field:** the metal (body) of a car changes the magnetic field above the sensor // the sensor detects this change when a car is over it // the change ends when the car leaves **Proximity:** detects that an object is close above it // how near the underside of the car is // nothing near means the space is free **Infra-red:** the underside of the car reflects / blocks infra-red (sent up from the sensor) // no reflection means the space is free **Any sensor:** it works without a person checking // it gives a reading for each space so the display can be kept up to date	**3**	max 3. The explanation must match the sensor named. Accept light (sensor) with the reason that the car blocks / shades the light reaching it. Do not accept motion sensor (a parked car does not move). Do not credit pressure (the wheels do not touch the sensor). Do not credit level, flow, gas, humidity or moisture.
6 0478 3.2.3(b)	Any four from: A humidity sensor measures (the amount of) water vapour / moisture in the air A moisture sensor measures the water content of the soil // how wet / dry the soil is The system needs to know whether the soil is dry // the plants take water from the soil (through their roots) The humidity of the air does not (reliably) show how wet the soil is // the air can be humid while the soil is dry (or the air dry while the soil is wet) ... so a humidity sensor could cause beds to be watered when they do not need it // not watered when they do A moisture sensor can be placed in (each) bed // in the soil near the roots, so it measures that bed directly	**4**	max 4. Max 2 if only one of the two sensors is described. Do not accept "a moisture sensor is more accurate" alone. Do not credit "a humidity sensor measures the water in the soil".

Total: 22 marks

MODULE J HARDWARE AND EMERGING TECH · J4

Automated systems: mark scheme

22 marks · Cambridge 0478 syllabus 6.1.1 (describe how sensors, microprocessors and actuators are used in collaboration to create automated systems; scenarios from industry, transport, agriculture, weather, gaming, lighting, science) and 6.1.2 (describe the advantages and disadvantages of an automated system used for a given scenario)

How to use. One mark per creditworthy point up to the maximum shown. **/** separates alternative words; **//** separates alternative answers. Words in (brackets) are not needed for the mark. "..." at the start of a point means it builds on the point before. Credit any other valid answer that shows the same understanding. Vague answers such as "it is faster", "it is cheaper" or "it is safer" on their own, with no reason, are not credited.

QUESTION	ANSWER	MARKS	GUIDANCE
1 0478 6.1.1	One mark for each correct row: Measures the amount of water in the soil: Sensor Compares a reading with a stored value and decides: Microprocessor Opens a valve when it receives a signal: Actuator Takes readings of the air pressure and sends them: Sensor	**4**	A row with more than one tick scores 0.
2 0478 6.1.1	Any two from: The (light) sensor only measures / detects the light level // only takes readings ... and sends the readings / data to the microprocessor The microprocessor compares the reading with a stored value // decides whether it is dark enough The microprocessor sends a signal to the actuator The actuator switches the floodlights on (not the sensor)	**2**	max 2. Do not accept "the sensor cannot switch things on" with no reference to what the sensor <u>does</u> or what does the switching.
3 0478 6.1.1	One mark for each correct word, in this order: continuously microprocessor compares actuator	**4**	Accept a grammatical variant of the correct word (e.g. "compare"). Do not accept words that are not in the list.

QUESTION	ANSWER	MARKS	GUIDANCE
4(a) 0478 6.1.2	Two marks per advantage: one for the advantage, one for the expansion in context. Any two from: It monitors the gas level 24 hours a day // all the time // without breaks ... so a dangerous gas level is not missed between employees' checks / at night It responds faster / immediately (when the gas level is too high) ... so the fans start sooner // harmful gas has less time to build up // drivers are exposed for less time Employees no longer need to walk through the tunnel ... so they are not exposed to the harmful exhaust gases / to traffic // it is safer for employees Readings / decisions are more consistent / accurate // there is no human error (e.g. misreading a meter, forgetting to switch on the fans) ... so the fans are switched on every time the level is too high Fewer employees are needed (to check the tunnel) ... so the cost of wages / labour (for the tunnel operator) is lower // employees can do other work Sensors can be placed all along the tunnel / take readings at many points at the same time ... so a high gas level anywhere in the tunnel is detected	**4**	max 4: max 2 per advantage. The expansion mark must follow from its own advantage. Two answers that make the same point score once. "Safer", "faster" or "cheaper" alone, with no reason, is not credited.
4(b) 0478 6.1.2	One mark for the disadvantage, one for the expansion in context. Any one pair from: It is expensive to buy / set up / install // to maintain / repair ... for example the sensors and fans need regular checks / calibration / replacing A sensor / the system could fail / malfunction / lose power ... so the fans are not switched on and harmful gas builds up // drivers / people in the tunnel are put at risk The system could be hacked // attacked ... and the fans switched off / the readings changed, putting people in the tunnel at risk Employees who checked the tunnel may lose their jobs ... so they need to find other work // need retraining (e.g. to maintain the system) It cannot deal with situations it was not programmed for ... such as a fire / crash / smoke, which may need a different response	**2**	max 2. The second mark must expand the disadvantage given. "It might break" with no consequence scores 1.

QUESTION	ANSWER	MARKS	GUIDANCE
5 0478 6.1.1	Any six from: The temperature sensor takes readings (of the temperature inside the incubator) ... continuously // at regular intervals The sensor sends the readings / data to the microprocessor The microprocessor compares each reading with stored values // with 36.5 °C and 37.5 °C // with the stored range If the reading is below 36.5 °C, the microprocessor sends a signal to the actuator to switch the heater on If the reading is above 37.5 °C, the microprocessor sends a signal to the actuator to switch the cooling fan on ... and the heater off // (when below 36.5 °C) the cooling fan off If the reading is within the range, no action is taken // the heater and fan stay off // the microprocessor waits for the next reading The process repeats (continuously) // it is a continuous loop // the system keeps monitoring and correcting (Analogue) readings are converted to digital (by an ADC) before the microprocessor processes them	**6**	max 6. The sensor must not be described as switching the heater or fan, and the actuator must not be described as taking readings. Do not credit "the sensor controls the temperature". Accept "too cold" / "below the range" and "too hot" / "above the range" in place of the temperatures in the heater and fan points. Reversed actions (fan on when too cold, heater on when too hot) score 0 for those points.

Total: 22 marks

MODULE J HARDWARE AND EMERGING TECH · J5

Robotics: mark scheme

20 marks · Cambridge 0478 syllabus 6.2.1 (what is meant by robotics), 6.2.2 (the characteristics of a robot: a mechanical structure or framework; electrical components such as sensors, microprocessors and actuators; programmable) and 6.2.3 (the roles robots perform in industry, transport, agriculture, medicine, domestic settings and entertainment, and the advantages and disadvantages of their use)

How to use. One mark per creditworthy point up to the maximum shown. **/** separates alternative words; **//** separates alternative answers. Words in (brackets) are not needed for the mark. Credit any other valid answer that shows the same understanding. Vague answers such as "it is better", "it is faster" or "it is cheaper" with no reason or context are not credited.

QUESTION	ANSWER	MARKS	GUIDANCE
1 0478 6.2.1, 6.2.2	One mark for each correct row: Robotics is a branch of computer science ... design, construction and operation of robots: **True** A machine can only be a robot if it is shaped like a human: **False** A robot follows a stored program, which can be changed ...: **True** In a robot, the actuators take readings from the surroundings ...: **False**	**4**	A row with both boxes ticked scores 0 for that row. Row 4 is false because sensors take readings; actuators carry out the movement / action.
2(a) 0478 6.2.2	One mark for each row, in context: **Mechanical structure or framework:** the jointed arm // the joints of the arm // the (metal) frame / body / base // the part that holds the nozzle **Electrical components:** a microprocessor (that controls the arm / runs the program) // sensor(s), e.g. a proximity sensor / camera, to detect the cake // actuators / (electric) motors that move the arm / joints // a pump / valve that pushes out the icing	**2**	The answer must describe a part of this robot, not repeat the characteristic. Do not credit the conveyor belt or the cakes for the mechanical structure. For row 2, naming one correct electrical component of the robot is enough.
2(b) 0478 6.2.2	Any two from: The robot follows a (stored) program // set of instructions (to pipe the pattern) The program can be changed // the robot can be reprogrammed // a new program can be loaded for the new pattern ... so the same robot can be used // no new robot / machine needs to be bought // no hardware / parts need to be changed The change can be made quickly // production only stops for a short time The new pattern is then piped exactly the same on every cake // consistently / precisely	**2**	max 2. "It can be programmed" alone repeats the question and is not credited.

QUESTION	ANSWER	MARKS	GUIDANCE
3 0478 6.2.2 (also 6.1.1)	Any four from: The proximity sensor takes readings // detects how near an object is (to the nozzle) The sensor sends the data / readings to the microprocessor Analogue data from the sensor is converted to digital (by an ADC) The microprocessor compares the reading with a stored / pre-set value // checks whether the reading shows a cake is (directly) under the nozzle If a cake is in position, the microprocessor sends a signal to the actuators ... the actuators (e.g. motors / pump / valve) start piping // move the arm / nozzle If there is no cake // the reading is outside the set range, no signal is sent // the actuators do not start // the robot waits The process repeats (continuously) // the sensor keeps taking readings	**4**	max 4. Do not credit "the sensor controls the actuators" or "the sensor decides": the microprocessor makes the decision. Do not credit "the microprocessor measures the distance".
4 0478 6.2.3	One mark for each correct row: Picks ripe strawberries in a greenhouse: **agriculture** Model dinosaur in a theme park: **entertainment** Driverless shuttle between airport terminals: **transport** Cuts the grass in the garden of a house: **domestic settings**	**4**	Accept "domestic" for domestic settings. Industry and medicine are not used. If more than one area is written in a row, that row scores 0.
5(a) 0478 6.2.3	One mark for an advantage and one mark for an expansion linked to it, in context. For example: The technician does not need to climb the turbine // work at height // the drone works in the dangerous place instead ... so there is less risk of the technician falling / being injured The drone can check the blades more quickly ... so more turbines can be checked in a day // each turbine is out of action for less time The drone can work at any time // without breaks // for long periods ... so checks can be done more often The drone takes the same images in the same way every time // is consistent / precise ... so damage is less likely to be missed // images can be compared between checks Lower labour / running costs over time ... because fewer technicians need to be paid to climb (the turbines)	**2**	max 2. The second mark must expand the advantage given. Credit any other valid advantage. "Cheaper" or "faster" alone is not credited.

QUESTION	ANSWER	MARKS	GUIDANCE
5(b) 0478 6.2.3	One mark for a disadvantage and one mark for an expansion linked to it, in context. For example: The drone is expensive to buy // to maintain / repair ... so there is a high initial cost for the company // staff need training to use it Technicians may lose their jobs // fewer technicians are needed ... so staff may need retraining // the company may need to make staff redundant The drone cannot deal with unfamiliar situations // only does what it is programmed to do ... so it may miss / not recognise an unusual type of damage that a technician would notice The drone cannot repair the damage ... so a technician still has to climb the turbine to fix it The drone may not be able to fly in strong wind / bad weather // has a limited battery life ... so checks may be delayed // it cannot check many turbines on one charge The drone may malfunction // crash into a blade ... and damage the turbine / drone	**2**	max 2. The second mark must expand the disadvantage given. Credit any other valid disadvantage. "It might break" alone is not credited.

Total: 20 marks

MODULE J HARDWARE AND EMERGING TECH · J6

What artificial intelligence is: mark scheme

20 marks · Cambridge 0478 syllabus 6.3.1 (what is meant by AI: a branch of computer science dealing with the simulation of intelligent behaviours by computers; limited to expert systems and machine learning) and 6.3.2 (the main characteristics of AI: the collection of data and the rules for using that data, the ability to reason, and it can include the ability to learn and adapt)

How to use. One mark per creditworthy point up to the maximum shown. **/** separates alternative words; **//** separates alternative answers. Words in (brackets) are not needed for the mark. **...** at the start of a point means it builds on the point above. Credit any other valid answer that shows the same understanding.

QUESTION	ANSWER	MARKS	GUIDANCE
1 0478 6.3.1, 6.3.2	One mark for each correct row: AI is a branch of computer science: True AI deals with the simulation of intelligent behaviours by computers: True A computer system must have a mechanical structure before it can use AI: False An AI system needs a collection of data, but it does not need any rules for using that data: False	**4**	A row with both boxes ticked, or no box ticked, scores 0 for that row. Row 3: a mechanical structure is a characteristic of a robot, not of AI.
2 0478 6.3.1	Any two from: Recognising speech // understanding spoken commands Recognising images // faces // objects Making decisions Solving problems Playing games (e.g. a board game against a person) Understanding / responding to (typed or written) language // holding a conversation // translating between languages Reasoning // reaching conclusions from facts Learning (from experience) // adapting behaviour // making predictions (from patterns in data)	**2**	max 2. Credit any other valid intelligent behaviour, including a correct named use (e.g. diagnosing a fault, recommending a product, driving a vehicle). Two answers that make the same point (e.g. "recognising faces" and "recognising objects") score 1. Do not accept "thinking" alone, "storing data" or "doing calculations".
3 0478 6.3.1 (AI limited to expert systems and machine learning)	One mark for each correct row: Adapts its own processes and/or data: machine learning Knowledge base, rule base, inference engine and interface: expert system	**2**	Accept "ML" for machine learning. Do not accept "AI" alone, "robot" or "learning system" for row 1, or "knowledge system" for row 2.
4 0478 6.3.2	One mark for each correct row: Stores parcel data and the 20 kg rule: (a) collection of data and (the) rules for using that data // (it has) data and rules Applies its rules to decide which van: (the) ability to reason // reasoning // (the) ability to make decisions Changes its own rule for the late town: (the) ability to learn // (the) ability to adapt // learning and adapting Reaches the conclusion about the quicker route: (the) ability to reason // reasoning // (the) ability to make decisions	**4**	Row 1: accept "collection of data" or "rules for using data" on its own. Row 3: accept "machine learning". Do not accept "simulation of intelligent behaviour" for any row.

QUESTION	ANSWER	MARKS	GUIDANCE
5(a) 0478 6.3.2	Any two from: It uses the data it has // the current positions of the pieces (on the board) // the moves made so far It applies its rules (for playing the game) to this data It works out / compares the possible moves // the likely result of each possible move It reaches a conclusion / decision about which move is best (and makes that move)	**2**	max 2. Accept a correct example of a rule being applied (e.g. "if a piece can be taken, it moves to protect it") for the rules point. Do not accept "it thinks about the move" with no reference to data, rules or a conclusion. Do not accept "it picks a move at random".
5(b) 0478 6.3.2	Any three from: It records / stores the moves made // the results of games it has played It finds which moves / patterns led to wins and which led to losses It changes / updates its own rules // data (from these results) ... without a person / programmer having to change the program // reprogram it ... so it avoids moves that lost games before // repeats / uses more often moves that won It adapts to how the (adult) player plays // learns the player's usual moves / strategies (and responds to them) ... so its decisions improve // become more accurate / successful the more games it plays	**3**	max 3. Do not accept "it gets smarter / better" alone with no explanation of how. Do not accept "a programmer adds new rules after each game" (that is not the system learning by itself).
6 0478 6.3.1, 6.3.2	Any three from: The ability to learn / adapt is not needed for a system to be AI // AI can include the ability to learn, but does not have to The system has a collection of data (e.g. opening times, the dishes and their ingredients) ... and (the) rules for using that data (written by staff) It has the ability to reason // it applies its rules to the guest's question (and its data) to reach a conclusion / an answer It simulates intelligent behaviour // it simulates a member of staff answering a question // it understands / responds to language	**3**	max 3. Award the "data" and "rules" points separately. Do not accept "the manager is wrong because all computers are AI". Do not accept "it will learn later": the scenario says it never changes its rules or data.

Total: 20 marks

MODULE J HARDWARE AND EMERGING TECH · J7

Expert systems: mark scheme

21 marks · Cambridge 0478 syllabus 6.3.2 (the main characteristics of AI: a collection of data and the rules for using that data, the ability to reason, and it can include the ability to learn and adapt) and 6.3.3 (the basic operation and components of AI systems; expert systems have a knowledge base, a rule base, an inference engine and an interface)

How to use. One mark per creditworthy point up to the maximum shown. **/** separates alternative words; **//** separates alternative answers. Words in (brackets) are not needed for the mark. **...** at the start of a point means it builds on the point before. Credit any other valid answer that shows the same understanding. Components must be named in full: "knowledge", "rules" or "engine" alone is not credited.

QUESTION	ANSWER	MARKS	GUIDANCE
1 0478 6.3.3	One mark for each correct line: inference engine → Applies the rules to the facts and to the user's answers to reach a conclusion knowledge base → Stores the facts about the specialist area interface → Lets the user enter data and shows the user questions and results rule base → Stores the rules that are used to reason with the facts	**4**	A component with more than one line drawn from it scores 0 for that component. "Automatically changes its own processes and data as it is given more data" describes machine learning and is not used.
2 0478 6.3.3	One mark for each correct row: Screen where the engineer taps Yes or No: interface "Pump type K normally runs at ...": knowledge base Part that decides which question to ask next: inference engine "IF the pump is vibrating AND ... THEN ...": rule base	**4**	A row with more than one tick scores 0.
3 0478 6.3.2	Any two characteristics, max 2 marks each (1 for the characteristic, 1 for how this expert system shows it): **A collection of data // stores facts** ... e.g. the knowledge base holds facts about pumps / faults (e.g. normal motor temperatures) **Rules for using the data** ... e.g. the rule base holds IF ... THEN rules linking symptoms to faults **The ability to reason // makes decisions** ... e.g. the inference engine applies the rules to the facts and the engineer's answers to reach a conclusion about the cause of the fault // to decide which question to ask next	**4**	max 4. One mark for naming or clearly stating each characteristic, one mark for describing how this expert system shows it. Accept a description in context without the exact syllabus wording. Accept "a collection of data and the rules for using that data" given as one characteristic: 1 mark for the characteristic, 1 for the knowledge base / rule base in context. Do not credit "it can learn and adapt": the scenario says the senior engineers add the new facts and rules, so the system does not change them itself. Do not credit "it thinks like a human" alone.

QUESTION	ANSWER	MARKS	GUIDANCE
4 0478 6.3.3	Any five from: The answer (Yes) is input through the interface ... and passed to the inference engine The inference engine searches / compares the answer with the facts in the knowledge base // links the answer to facts about copper-bearing rocks / minerals The inference engine applies the rules in the rule base (to the facts and the answer) // e.g. IF green minerals AND ... THEN copper (likely) It uses this answer together with the previous answers (given by the geologist) If there is not enough data to reach a conclusion // more than one result is still possible, it chooses the next question to ask ... based on the answers given so far ... and the (next) question is displayed on the interface If the conditions of a rule are met, it reaches a conclusion / decision (e.g. the site is likely // not likely to contain copper) ... and the conclusion / suggestion is output on / displayed by the interface The output may show how likely the result is // how the result was reached	**5**	max 5. A component named with no description of what it does with the answer scores 0, so a bare list of the four components scores 0. Do not credit "the knowledge base decides" or "the rule base stores the facts" (components confused). Accept "user interface" for interface.
5(a) 0478 6.3.3	Any two from: Displays / asks the questions to the technician / user Lets the technician / user input data // answers // details of the problem / symptoms Outputs / displays the result // conclusion // the likely fault // advice on what to repair Displays an explanation of how the result was reached	**2**	max 2. Two answers that make the same point (e.g. "shows questions" and "displays questions") score 1. Do not credit "decides the fault" or "stores the rules" (that is the inference engine / rule base).
5(b) 0478 6.3.3	Any two from: The answers so far are not enough (data) to reach a conclusion // more than one fault is still possible // the answers match more than one rule A rule needs more facts / conditions to be checked before it gives a result // the conditions of a rule have not all been met / checked yet The (next) question gets the missing data // narrows down / rules out possible faults The inference engine chooses the next question based on the previous answers	**2**	max 2. Do not credit "the system is slow", "to check the technician's answers are correct" or "so it can learn".

Total: 21 marks

MODULE J HARDWARE AND EMERGING TECH · J8

Machine learning: mark scheme

22 marks · Cambridge 0478 syllabus 6.3.2 (main characteristics of AI: the collection of data and the rules for using that data, the ability to reason, the ability to learn and adapt) and 6.3.3 (basic operation and components of AI systems, limited to expert systems and machine learning; machine learning is when a program has the ability to automatically adapt its own processes and/or data)

How to use. One mark per creditworthy point up to the maximum shown. **/** separates alternative words; **//** separates alternative answers. Words in (brackets) are not needed for the mark. "..." at the start of a point means it builds on the point before. Credit any other valid answer that shows the same understanding. In the scenario questions (3(b), 4 and 5), an answer that is not linked to the scenario is capped as shown in the guidance.

QUESTION	ANSWER	MARKS	GUIDANCE
1(a) 0478 6.3.3	Any two from: A program / (AI) system that can adapt / change its own processes // its own data // its own rules ... automatically // by itself // without a programmer rewriting / reprogramming it It learns from data // from experience // from the results of its past decisions / mistakes It finds / identifies patterns in data ... so that its performance improves // it makes better decisions / predictions over time	**2**	max 2. "It learns" alone, with no reference to data, experience or adapting, is too vague. Do not credit "a robot" or "a computer that thinks like a human".
1(b) 0478 6.3.2	The ability to learn // the ability to adapt // the ability to learn and adapt	**1**	Do not credit "the ability to reason" or "the collection of data and rules".
2 0478 6.3.3	One mark for each correct row: Facts gathered from human experts, stored in a knowledge base: expert system Automatically changes its own processes as it is given more data: machine learning Inference engine applies a rule base to the facts: expert system Finds patterns in the results of past decisions to make better decisions: machine learning	**4**	A row with both boxes ticked scores 0.
3(a) 0478 6.3.2	Any two from: The photos (taken by the cameras) // features in the photos, e.g. the size / shape / colour / markings of the animal The species it identified for each photo // its past identifications The corrections made by the volunteer // the correct species for a photo // whether each identification was right or wrong The time / date / season a photo was taken The location / which camera / which part of the forest took the photo	**2**	max 2. Credit any other valid item of data that the software could have in this scenario. Two answers that are the same item (e.g. "colour of the animal" and "shape of the animal", both features in the photo) score 1. Do not credit "data" or "information" alone.

QUESTION	ANSWER	MARKS	GUIDANCE
3(b) 0478 6.3.3	Any four from: The software collects / stores data from (each new) photo // stores its identifications It uses the volunteer's corrections to find out which identifications were wrong // stores successful / unsuccessful identifications It finds / identifies patterns, e.g. features that a species has in common // features that led to mistakes It (automatically) adapts / changes its own processes // its own data // its own rules for identifying a species ... without a programmer having to rewrite / reprogram the software ... so it does not repeat the same mistake // it makes fewer wrong identifications The more photos / corrections it receives, the more data it has to learn from // it keeps improving as new photos arrive	**4**	max 4. Max 2 if the answer is not linked to the photos, species or corrections in the scenario. Do not credit "the volunteer reprograms the software": correcting an identification gives the software data, it does not rewrite the program.
4 0478 6.3.2	One mark for each different characteristic (max 3): Collection of data // stores data Rules for using the data // has rules Ability to reason // makes decisions / predictions // solves problems Ability to learn / adapt One mark for each matching description in context (max 3): **Collection of data:** stores data about the vans (e.g. route / space / weight limit) and the parcels (e.g. size / weight / address) // records which parcels were late **Rules:** has rules such as which area each van covers // a parcel must fit in the van's free space **Reason:** applies the rules to the data (about a new parcel) to decide which van it goes on // works out the best van for each parcel **Learn and adapt:** uses the record of late deliveries to change how it chooses vans // adapts its own rules / data so fewer parcels are late // does not repeat a choice that led to a late delivery	**6**	max 6. Characteristics may be given in any order. A description is credited only if it matches the characteristic in the same row and is linked to the parcel depot. A characteristic repeated in two rows is credited once. Collection of data and rules for using the data may be given as two separate characteristics or as one; if both are given in one row, credit one characteristic mark for that row. Do not credit "it is intelligent" or "it thinks like a human" as a characteristic.

QUESTION	ANSWER	MARKS	GUIDANCE
5 0478 6.3.3	Any three from: It collects / records data about when staff arrive / leave // the temperature (inside the building) // how long the building takes to warm up It finds / identifies patterns in the data, e.g. staff usually arrive at the same time on weekdays // nobody arrives at weekends It uses the patterns to predict when staff will arrive ... and switches the heating on early enough that the building is warm when staff arrive // does not heat the building when it is empty It (automatically) adapts / changes its own processes // its own data // its heating times when the pattern changes, e.g. staff start arriving earlier ... without anyone having to program / enter heating times	**3**	max 3. Max 1 for a generic description of machine learning that is not linked to the heating, the staff or the temperature. Do not credit "a person sets the heating times".

Total: 22 marks