1.15 Responsive materials

AQA 8552 · Calculator allowed · about 50 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions.

1 A strip made from fictional material LumaFlex becomes paler under ultraviolet (UV) light and returns to its original colour in indoor shade. Identify the stimulus and the response. [2 marks]

(Total for Question 1 is 2 marks)

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2 For a fictional shape-responsive panel, the same sample was tested once at each temperature. Mean measured bend was 1 mm at 20 C and 8 mm at 40 C. Explain what the results suggest and give two limitations when predicting performance in a product. [4 marks]

(Total for Question 2 is 4 marks)

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3 A fictional coating changes colour above 38 C in a single laboratory trial. A designer proposes printing 'safe to touch' on a product whenever the coating shows its changed colour. Evaluate this proposal using the supplied information and state one test or evidence need. [4 marks]

(Total for Question 3 is 4 marks)

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4 A fictional reversible shape-change material called LoopForm is proposed for a reusable packaging tab. In a supplied test it bends by 9 mm when warmed from 20 C to 45 C and returns to within 1 mm of its original position after cooling to 20 C. Recommend whether to continue developing it for this use. Give two data-based reasons and one further test. [5 marks]

(Total for Question 4 is 5 marks)

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5 A fictional sheet called ThermoWeave curls when warmed and lies flat again when cooled. Explain what makes this a reversible response and state one observation that would indicate that it was not fully reversible. [3 marks]

(Total for Question 5 is 3 marks)

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6 Fictional colour-responsive films are being considered for a reusable display card that should show a colour change between 24 C and 30 C, then return to its starting colour below 22 C. Film P changes colour from 25 C to 29 C and recovers below 21 C. Film Q changes from 18 C to 24 C and recovers below 16 C. Select the closer match and give one reason. These films are not certified safety indicators. [3 marks]

(Total for Question 6 is 3 marks)

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7 In a fictional test, four FlexiTrace strips were each warmed to 40 C and then cooled to 20 C. Their measured bends at 40 C were 11, 12, 10 and 11 mm; after cooling they measured 1, 0, 1 and 2 mm. Describe the pattern and explain one conclusion the data support. [3 marks]

(Total for Question 7 is 3 marks)

8 A fictional plate called FlexiTrace curves when heated to 35 C and returns towards flat when cooled to 20 C. Explain why its change is a material response rather than a separate electronic sensor reading, and identify the stimulus and response. [3 marks]

(Total for Question 8 is 3 marks)

9 A fictional sample of ShapeReturn polymer is 120 mm long before heating. It reaches 132 mm at 50 C and measures 123 mm after cooling to 20 C. Calculate its extension at 50 C and its residual extension after cooling. [3 marks]

(Total for Question 9 is 3 marks)

10 A fictional reversible colour film was cycled between 20 C and 32 C five times. Its measured colour-change intensity on the five cycles was 80, 78, 75, 71 and 68 arbitrary units. Calculate the decrease from cycle 1 to cycle 5 and state what the results suggest. [3 marks]

(Total for Question 10 is 3 marks)

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11 A fictional test records the temperature at which a colour-responsive coating first changes. The five results are 26 C, 27 C, 25 C, 28 C and 24 C. Calculate the mean change temperature and the range. [3 marks]

(Total for Question 11 is 3 marks)

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12 A fictional colour-changing coating is intended for a decorative mug sleeve, with a visible response from 35 C to 45 C and recovery below 30 C. Batch A has a change range of 36 C to 44 C and recovered below 29 C. Batch B has a change range of 31 C to 40 C and recovered below 28 C. Choose the better match and give one limitation of the supplied data. [4 marks]

(Total for Question 12 is 4 marks)

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Mark scheme · 1.15 Responsive materials

Question 1

Stimulus: ultraviolet light or change in UV exposure	**B1**
Response: the strip becomes paler (and returns to its original colour in shade)	**B1**

Answer: Stimulus: UV light. Response: the LumaFlex strip becomes paler; it returns to its original colour in shade.

Question 2

States the panel bent more at 40 C than at 20 C	**B1**
Links this difference to a possible temperature-responsive change under the stated test	**B1**
Identifies one limitation: only one sample or no repeat tests/uncertainty information	**B1**
Identifies a distinct limitation: only two temperatures, or no information about recovery, duration, ageing or finished-product conditions	**B1**

Answer: The panel bent more at 40 C (8 mm) than at 20 C (1 mm), suggesting a temperature-associated change under these test conditions. Confidence is limited because only one sample and no repeats are reported. Two test temperatures also do not show the response between them or whether the panel returns after cooling.

Question 3

States that a colour change above 38 C was observed in one trial	**B1**
Explains that this does not establish a safe-touch temperature or certify safety	**B1**
Identifies a relevant limitation such as one trial, no uncertainty, no surface-temperature calibration or no test across use conditions	**B1**
Proposes relevant additional evidence, such as repeated calibrated surface-temperature tests across conditions and an appropriate safety assessment	**B1**

Answer: The single trial suggests that the fictional coating changed colour above 38 C in that test. It does not show that the product is safe to touch at that colour, or establish a certified safety threshold. Repeat calibrated tests of surface temperature under intended use conditions and an appropriate safety assessment would be needed.

Question 4

Makes a clear conditional recommendation to continue development or not proceed yet	**B1**
Uses the 9 mm warmed bend as evidence of a measurable response	**B1**
Uses the return to within 1 mm after cooling as evidence of near-return in the supplied test	**B1**
Identifies a relevant limitation, such as only one test/sample, unknown cycle durability or untested actual tab loads	**B1**
Proposes a relevant further test, such as repeated heating/cooling cycles under representative tab loads	**B1**

Answer: Continue development as a candidate: it bends by 9 mm when warmed and returns to within 1 mm after cooling in the supplied test. This is promising evidence for a responsive reusable tab, but it does not establish performance in use. Test repeated cycles under representative loads and inspect for loss of movement or damage.

Question 5

Identifies warming or temperature increase as the stimulus	**B1**
Explains that cooling restores the original flat form after curling	**B1**
Gives a relevant sign of incomplete return, such as remaining curled, cracking or not returning to the original shape	**B1**

Answer: Warming is the stimulus and curling is the response. The behaviour is reversible because cooling returns the sheet to its original flat form. A remaining curl after cooling would show incomplete return.

Question 6

Selects Film P	**B1**
Links P's 25 C to 29 C change range to the requested 24 C to 30 C range	**B1**
Notes its below-21 C recovery condition is close to the requested below-22 C condition, or identifies a relevant limitation in the match	**B1**

Answer: Film P is the closer match: its 25 C to 29 C change range lies within the requested 24 C to 30 C range, and it recovers below 21 C, close to the requested below 22 C. The supplied fictional data do not establish safety performance or certification.

Question 7

Describes that all four strips bent substantially more at 40 C than after cooling	**B1**
States that cooled bends were small, from 0 mm to 2 mm, compared with 10 mm to 12 mm when warm	**B1**
Concludes the response largely reversed in these four tests, bounded to these conditions/samples	**B1**

Answer: All four strips bent more when warm (10 mm to 12 mm) than after cooling (0 mm to 2 mm). This supports a largely reversible response for these samples over this test cycle, but does not establish behaviour in other conditions or repeated cycles.

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Question 8

Identifies temperature or heating as the stimulus	**B1**
Identifies the plate's own curvature change as the response	**B1**
Explains that the observed response is a physical change in the material itself, with no separate sensor reading described	**B1**

Answer: Temperature increase is the stimulus. The plate's curvature is the response. The described output is the plate itself changing shape, rather than an electronic sensor producing a separate reading.

Question 9

Uses 132 - 120 for extension when heated	**M1**
Heated extension = 12 mm	**A1**
Residual extension = 123 - 120 = 3 mm	**A1**

Answer: Extension at 50 C: 132 - 120 = 12 mm. Residual extension after cooling: 123 - 120 = 3 mm.

Question 10

Subtracts cycle 5 value from cycle 1 value	**M1**
Decrease = 80 - 68 = 12 arbitrary units	**A1**
Recognises a downward trend in measured intensity across these five cycles, without claiming its cause	**B1**

Answer: The measured intensity decreased by 80 - 68 = 12 arbitrary units. The readings show a downward trend over the five tested cycles; they do not explain why it occurred.

Question 11

Adds the five readings and divides by 5	**M1**
Mean = 130 / 5 = 26 C	**A1**
Range = 28 - 24 = 4 C	**A1**

Answer: Mean = (26 + 27 + 25 + 28 + 24) / 5 = 130 / 5 = 26 C. Range = 28 - 24 = 4 C.

Question 12

Chooses Batch A	**B1**
Compares its 36 C to 44 C response range with the target 35 C to 45 C range	**B1**
Compares its below-29 C recovery with the requested below-30 C condition	**B1**
Identifies a limitation such as no sample count, cycle durability, visibility measurement or test uncertainty being supplied	**B1**

Answer: Batch A is the better match: its 36 C to 44 C response range lies within the target range and it recovers below 29 C, close to the target below 30 C. The data do not state sample counts or repeat-cycle durability, so consistency is unknown.

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