HIGHER

B5H Homeostasis and Response: Higher Tier Practice

AQA 8461 · Calculator allowed · about 95 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 The human body maintains a fairly constant internal temperature. Describe two ways the body reduces heat loss when core temperature falls below the normal set point.

(a) Describe one change in blood vessels that reduces heat loss. **(1)**

(b) Describe one muscular response that reduces heat loss. **(1)**

(c) Give one behavioural change a person might use to reduce heat loss. **(1)**

(Total for Question 1 is 3 marks)

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2 A student draws the pathway for a simple reflex arc: receptor -> sensory neurone -> spinal cord -> motor neurone -> effector.
State the type of effector for a reflex that moves the hand away from a hot object, and name the neurotransmitter commonly released at the neuromuscular junction.

(a) State the type of effector that moves the hand away. **(1)**

(b) Name the neurotransmitter commonly released at the neuromuscular junction to cause muscle contraction. **(2)**

(Total for Question 2 is 3 marks)

3 Insulin and glucagon are hormones that control blood glucose concentration. A person has a fasting blood glucose concentration of 4.8 mmol per litre. After eating, their blood glucose rises to 8.6 mmol per litre. Calculate the percentage increase in blood glucose concentration. Show your working.

(a) Calculate the percentage increase from 4.8 mmol per litre to 8.6 mmol per litre. Show working and give the answer to 2 significant figures. **(4)**

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(Total for Question 3 is 4 marks)

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4 A student models kidney function with an experiment. They filter a protein solution through a membrane that mimics the glomerulus: only molecules smaller than 70 kDa pass. Which of the following molecules would be present in the filtrate? Circle all correct answers.

A: Urea (60 Da)
B: Albumin (66 kDa)
C: Glucose (180 Da)
D: Immunoglobulin G (150 kDa)
E: Fructose (180 Da)

State the letters of the correct choices.

(a) State the letters of the molecules that would pass through the membrane. **(3)**

- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ E

(Total for Question 4 is 3 marks)

5 ADH affects the permeability of the collecting duct in the kidney. Explain how a rise in blood osmolality leads to increased water reabsorption by the collecting duct. Your answer should include the roles of osmoreceptors, ADH and aquaporins.

(a) Explain the sequence from increased blood osmolality to increased water reabsorption. **(4)**

(Total for Question 5 is 4 marks)

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6 A patient with untreated type 1 diabetes has a blood glucose concentration of 20.0 mmol per litre. During a test, 2.00 litres of blood plasma are filtered per minute through the glomerulus and none of the excess glucose is reabsorbed because transporters are saturated.
Calculate the mass of glucose (in grams) lost in urine in one hour. (Molar mass of glucose = 180 g per mol). Show working and include units.

(a) Calculate the mass of glucose lost in urine in one hour, given filtration rate 2.00 L per minute and blood glucose 20.0 mmol per litre. Show all working and give answer to 3 significant figures. **(5)**

(Total for Question 6 is 5 marks)

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7 Describe how a negative feedback mechanism restores blood glucose concentration after a meal. Include the roles of insulin and glycogen.

(a) Describe the key steps of the negative feedback control of blood glucose after a meal. **(3)**

(Total for Question 7 is 3 marks)

8 A student investigates the effect of ADH on water loss using two groups of model collecting duct cells. Group 1 receives no ADH. Group 2 receives ADH and the rate of water movement through the cells is measured. The student reports: Group 1 water movement 0.12 ml per minute, Group 2 water movement 0.46 ml per minute.
Calculate the fold increase in water movement when ADH is present. Show working and give answer to 2 significant figures.

(a) Calculate the fold increase (Group 2 divided by Group 1) and give answer to 2 significant figures. **(4)**

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(Total for Question 8 is 4 marks)

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9 A graph shows how a person's blood glucose changes during an oral glucose tolerance test (OGTT). The data points are: time 0 min: 4.5 mmol per L; 30 min: 9.2 mmol per L; 60 min: 7.0 mmol per L; 120 min: 5.0 mmol per L.
Calculate the area under the curve (AUC) using the trapezium rule between 0 and 120 minutes in mmol per L x min. Use intervals [0-30], [30-60], [60-120]. Show working.

(a) Calculate the AUC using trapezium rule for the three intervals and give the total to 3 significant figures. **(4)**

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(Total for Question 9 is 4 marks)

10 Explain how the pancreas and liver work together to keep blood glucose concentration within normal limits over a 24 hour period. In your answer you should explain hormonal control and include reference to homeostasis and negative feedback.

(Total for Question 10 is 6 marks)

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11 A biologist investigates how plant root cells respond to different external sucrose concentrations to model osmoregulation. They place equal masses of potato cylinders in three sucrose solutions and measure percentage change in mass after 40 minutes. The results are:
0.0 mol per L: +6.0%
0.25 mol per L: +1.0%
0.50 mol per L: -4.0%
0.75 mol per L: -10.0%
Use the data to:
a) Estimate the sucrose concentration of the potato cell sap (the concentration where no net mass change would occur). b) Suggest two experimental improvements to reduce random error in this practical.

(a) Estimate the sucrose concentration of the potato cell sap by interpolation between the two nearest points. Show working and give answer to 2 decimal places in mol per litre. **(4)**

(b) Suggest two improvements to the experimental method to reduce random error. **(3)**

(Total for Question 11 is 7 marks)

12 A new drug mimicking adrenaline is given to volunteers and heart rate is measured. The data show a mean increase in heart rate of 22 beats per minute with a standard deviation of 6 bpm. A student claims this drug always increases heart rate by at least 20 bpm. Using the mean and standard deviation, calculate the z-score for the difference between the observed mean (22 bpm) and the student's claim (20 bpm). State whether the data support the student's claim at the level of one standard deviation.

(a) Calculate the z-score: (observed mean - claimed value) / standard deviation. Give answer to 2 decimal places. **(3)**

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(b) State whether the data support the claim at the level of one standard deviation and justify briefly. **(1)**

(Total for Question 12 is 4 marks)

Mark scheme · B5H Homeostasis and Response: Higher Tier Practice

Question 1

- (a) **B1** vasoconstriction of arterioles near the skin reducing blood flow to the skin, oe
- **(a) Answer: Vasoconstriction of arterioles near the skin so less warm blood reaches the surface.**
- (b) **B1** shivering: involuntary muscle contractions produce extra heat, oe
- **(b) Answer: Shivering: involuntary rapid muscle contractions that generate heat.**
- (c) **B1** putting on extra clothes, moving to a warmer place, or wrapping in a blanket, oe
- **(c) Answer: Put on extra clothing (for example, wear a jumper or wrap a blanket).**

Question 2

- (a) **B1** skeletal muscle (or voluntary muscle) cao
- **(a) Answer: Skeletal muscle**
- (b) **M1** identifies acetylcholine as the neurotransmitter released at the neuromuscular junction
- (b) **A1** acetylcholine cao
- **(b) Answer: Acetylcholine**

Question 3

- (a) **M1** calculates change: 8.6 - 4.8 = 3.8 mmol per litre
- (a) **M1** divides by initial value: 3.8 / 4.8
- (a) **A1** 0.79 (or 79) cao to 2 s.f.
- (a) **A1** gives percentage: 79% cao
- **(a) Answer: 79%**

Question 4

- (a) **B1** A (urea) passes - 60 Da is much smaller than 70 kDa
- (a) **B1** C (glucose) passes - 180 Da is much smaller than 70 kDa
- (a) **B1** E (fructose) passes - 180 Da is much smaller than 70 kDa
- **(a) Answer: A, C, E**

Question 5

- (a) **M1** states osmoreceptors in the hypothalamus detect increased blood osmolality
- (a) **M1** states pituitary releases more ADH into the blood
- (a) **M1** states ADH binds to receptors on collecting duct cells causing insertion of aquaporins into the membrane
- (a) **A1** concludes that water permeability of the collecting duct increases so more water is reabsorbed back into the blood, reducing osmolality cao
- **(a) Answer: Osmoreceptors detect higher osmolality, the pituitary releases more ADH, ADH binds collecting duct cells causing aquaporins to be inserted, increasing water reabsorption.**

Question 6

- (a) **M1** converts filtration to litres per hour: 2.00 L per min x 60 = 120 L per hour
- (a) **M1** calculates amount of substance in mmol: 20.0 mmol per L x 120 L = 2400 mmol
- (a) **M1** converts mmol to mol: 2400 mmol = 2.400 mol
- (a) **A1** calculates mass: 2.400 mol x 180 g per mol = 432 g cao
- (a) **A1** gives final answer with unit: 432 g cao
- **(a) Answer: 432 g**

Question 7

- (a) **M1** states rise in blood glucose after a meal is detected by pancreas β cells
- (a) **M1** states insulin is secreted, causing cells to take up glucose and the liver to convert glucose to glycogen
- (a) **A1** concludes that blood glucose falls back toward the set point, completing negative feedback, oe
- **(a) Answer: Pancreatic β cells detect the rise, secrete insulin which increases cellular glucose uptake and stimulates the liver to store glucose as glycogen, returning glucose toward the set point.**

Question 8

- (a) **M1** divides rates: 0.46 / 0.12
- (a) **M1** evaluates division: 3.8333...
- (a) **A1** gives fold increase to 2 s.f.: 3.8 cao
- (a) **A1** includes unitless justification or 'fold' as unit: 3.8-fold cao
- **(a) Answer: 3.8-fold**

Question 9

- (a) **M1** applies trapezium for 0-30: (4.5 + 9.2) / 2 x 30 = 13.05 x 30? (evidence of calculation shown)
- (a) **M1** applies trapezium for 30-60: (9.2 + 7.0) / 2 x 30
- (a) **M1** applies trapezium for 60-120: (7.0 + 5.0) / 2 x 60
- (a) **A1** adds intervals correctly and gives AUC = 809 mmol per L x min to 3 s.f. cao
- **(a) Answer: 809 mmol per L x min**

Question 10

- **Level 3** (5-6): Detailed explanation that links pancreatic detection, hormonal responses (insulin and glucagon), liver glycogen storage and release, and negative feedback restoring blood glucose. Good use of scientific terms and clear mechanism.
- **Level 2** (3-4): Partial explanation with two correct linked points, for example description of insulin lowering glucose and glucagon raising it, but limited detail on liver processes or negative feedback.
- **Level 1** (1-2): Basic statements such as 'insulin lowers blood sugar' or 'glucagon raises blood sugar' with little or no explanation of mechanisms or negative feedback.
- **Indicative content:**
  - Pancreas contains beta cells that detect high blood glucose and secrete insulin; alpha cells detect low glucose and secrete glucagon.
  - Insulin promotes uptake of glucose into muscle and adipose tissue and stimulates liver to convert glucose to glycogen (glycogenesis).
  - Glucagon stimulates liver to break down glycogen to glucose (glycogenolysis) and to form glucose from non-carbohydrate sources (gluconeogenesis).
  - Negative feedback: a rise in glucose increases insulin secretion which reduces glucose toward set point; a fall increases glucagon secretion which raises glucose toward set point.
  - Homeostasis term: maintenance of stable internal environment; hormonal signalling via blood provides slower but long-lasting control compared with nervous responses.
  - Mention of time course over day: after meals insulin dominant for storage; during fasting glucagon dominant to maintain supply for brain and organs.

Question 11

- (a) **M1** identifies interval where mass change crosses zero between 0.25 mol per L (+1.0%) and 0.50 mol per L (-4.0%)
- (a) **M1** uses linear interpolation: fraction = 1.0 / (1.0 + 4.0) = 1/5 = 0.2 from 0.25 toward 0.50
- (a) **M1** calculates concentration: 0.25 + 0.2 x (0.50 - 0.25) = 0.25 + 0.05 = 0.30 mol per L
- (a) **A1** gives final answer 0.30 mol per L cao
- **(a) Answer: 0.30 mol per L**
- (b) **B1** use more replicates for each concentration and average the results
- (b) **B1** use cylinders of exactly the same length and diameter and dry blotting technique consistently to remove surface solution
- (b) **B1** ensure temperature is kept constant or use a thermostatic water bath, oe
- **(b) Answer: Any two of: use more replicates and average results; cut cylinders to identical dimensions and blot consistently; keep temperature constant.**

Question 12

- (a) **M1** substitutes: (22 - 20) / 6
- (a) **M1** evaluates: 2 / 6 = 0.3333...
- (a) **A1** gives z = 0.33 to 2 d.p. cao
- **(a) Answer: 0.33**
- (b) **B1** yes: observed mean 22 is within one standard deviation above the claimed 20 (z = 0.33 < 1), so the claim that mean increase is at least 20 bpm is supported by these data at the one standard deviation level, oe
- **(b) Answer: Yes. z = 0.33 which is less than 1, so the observed mean is within one standard deviation of the claim and supports it.**