

6.4 Organisms - Responses to their environment (A-Level Only) - Homeostasis 1 – Mark schemes

Q1.

- (a) 1. Binding (of interferon gamma) changes shape/tertiary structure of receptor (protein);
2. This activates/switches on the enzyme;
3. Use of ATP (to phosphorylate STAT1);
1. Accept reference to second messenger mechanism/process
3. Context is important

2 max

- (b) 1. Phosphorylated STAT1;
2. IRF (protein);
Accept in either order
1. Must be phosphorylated but accept STAT1P
2. Ignore references to phosphorylated

2

- (c) 1. Causes more helper T cells to form;
2. (So) more interferon (gamma) production (by helper T cells);
1. and 2. require idea of more

2

- (d) 1. (Tumour suppressor gene) slows cell division/causes death of damaged/tumour/cancer cells;
2. *IRF* gene leads to formation of IRF (protein) that binds to gene B;
3. (Gene B protein) causes death of damaged/mutated cells OR slows division;
2. 'It' means IRF gene
3. Context is important
*3. If clearly stated **and** includes the protein, scores 2 marks because it subsumes point 1*

3

[9]

Q2.

- (a) 1. Release of glucagon;
2. Leads to formation of glucose in liver (cells);
Reject: glucagon breaks down glycogen, or any other biological molecule
3. From non-carbohydrates / amino acids / fatty acids.
Accept: gluconeogenesis / references to glycogen as source of glucose

3

- (b) 1. Mutant mice (mRNA suggests) make a lot of (the) enzyme;
Accept: PCK1 made (for enzyme made)
2. Mutant mice use kidney / intestine (cells) to make glucose;

Accept: use other organ (than liver)

3. Normal mice do this much less / normal mice use liver cells.

3

(c) 1. Differences significant;

Reject: references to results being significant once

2. Probability of difference being due to chance less than 0.01 / 1% / 1 in 100 / probability of difference not being due to chance more than 0.99 / 99% / 99 in 100.

Ignore: references to 0.05 / 5% / 5 in 100

2

[8]

Q3.

(a) 1. (Acetylcholine) released from / in presynaptic side;

2. Receptors in postsynaptic (side) / binds on postsynaptic (side);

2. Mark for diffusion only awarded in context of unidirectional movement.

2

(b) (i) 1. Rapid response;

2. Short duration;

Specific wording is not important. It is the principles that matter here.

Points may be made by referring to figures.

2

(ii)

	1	2	3
Percentage	80	0	0

Ignore % sign.

1

[5]

Q4.

(a) (i) Eaten;

Containing carbohydrate / sugar;

Glucose absorbed from intestine / into blood;

Long time after insulin injection / needs more insulin / has not taken insulin;

Does not convert glucose to glycogen / glucose not taken up from blood;

2 max

(ii) Shows positive correlation / directly proportional;

A range of results for a particular value / values (for different colours) overlap;

Urine test only an arbitrary scale / not directly related to concentration / colour is subjective / few colour values;

Accept description

3

- (b) Glycogen to glucose / glycogenolysis by activating enzymes;
If name incorrect this disqualifies.

Gluconeogenesis;

Allow explanation in terms of glucose from a non-carbohydrate / named non-carbohydrate source.

2

[7]

Q5.

- (a) (i) where a change triggers a response which reduces the effect of a change;

1

- (ii) e.g. sweating, breathing, defaecating, other valid example;
*(reject respiration
evaporation not acceptable as a 2nd mark if sweating or
breathing given)*

2 max

- (iii) hypothalamus;

1

- (b) (i) pituitary;

(ignore anterior pituitary)

1

- (ii) 1. ADH causes vesicles containing aquaporins / aquaporins to be inserted into membrane / collecting duct wall / plasma;
2. water enters cell through aquaporins;
3. by osmosis / diffusion / down a water potential gradient;
4. (from cell) to capillary;
5. via interstitial fluid;

4 max

- (c) (i) excessive urination / drinking / diluted urine / thirst;

1

- (ii) because males only have one X chromosome / do not have Y chromosome;
a single copy of the recessive allele will be expressed;

2

- (iii) recessive alleles can be carried by individuals without showing effects / dominant allele always expressed;
organism that are carriers more likely to reproduce / affected organism less likely to reproduce;
therefore recessive alleles are more likely to be passed on / dominant alleles less likely to be passed on;

3

[15]

Q6.

Quality of Communication

The answers to all sections of this question require the use of continuous prose. Quality of language should be considered in crediting points in the scheme. In order to gain credit, answers should be expressed logically and unambiguously, using scientific terminology where appropriate.

- (a)
1. Deviation of a value from norm initiates corrective mechanisms;
 2. fluctuations in plasma glucose concentration detected by hypothalamus / islet cells in pancreas;
 3. initial decrease, no food given (in plasma glucose) stimulates (increased) secretion of glucagon;
 4. increases (in plasma glucose) stimulate (increased) secretion of insulin from β cells as secretors;
 5. correct ref. to interconversion of glycogen / glucose / increased / decreased uptake of glucose by cells (as appropriate) / correct ref to change in membrane permeability;

5

- (b)
1. Body temp. / 37 °C is optimum temp for enzymes;
 2. excess heat denatures enzymes / alters tertiary structure / alters shape of active site / enzyme so substrate cannot bind / eq;
 3. reactions cease / slowed;
 4. too little reduces kinetic energy of molecules / molecules move more slowly;
 5. fewer collisions / fewer ES complexes formed'

5

[10]

Q7.

- (a) Hypothalamus.

1

- (b)
1. Water potential of blood will decrease;
 2. Water moves from osmoreceptor into blood by osmosis.

2

- (c)
1. Permeability of membrane / cells (to water) is increased;
 2. More water absorbed from / leaves distal tubule / collecting duct;
 3. Smaller volume of urine;
 4. Urine becomes more concentrated.

4

- (d) 115.2 / 115.3 (cm³ minute⁻¹).

1

- (e) Any **two** of the following for 1 mark:
 Muscle / body mass
 Ethnicity
 Exercise
Kidney disease – do not accept 'health'.

1

[9]

Q8.

- (a) Water is also reabsorbed

1

- (b)
1. Concentration rises in descending limb because sodium ions enter and water lost;

2. Concentration falls in ascending limb because sodium ions (and chloride) ions actively removed;
 3. But water remains (in ascending limb) because its walls are impermeable (to water).
- 3
- (c) 1. Concentration rises in collecting duct because it loses water by osmosis;
2. ADH increases permeability (of walls of collecting duct) to water.
- 2

[6]

Q9.

- (a) 1. Treat with insulin (injection/infusion);
2. (Control) diet/control sugar intake;
2. Accept 'regular exercise'
- 2
- (b) 1. Damage to autonomic (nervous) system in diabetic rats;
2. (Could be) pressure receptors/baroreceptors (in arteries/aorta/carotid body) don't work as well;
3. Damage to medulla

OR

Change in (number of) impulses to/from medulla;

4. (When pressure drops damage to) sympathetic system, so doesn't speed up (enough);
5. (When pressure rises damage to) parasympathetic system, so doesn't slow down (enough);

*Accept answers in terms of what happens in healthy rats
only if then qualified by statement these things don't happen/happen less in rats with diabetes*

1. Accept damage to ANS

2. Ignore reference to chemoreceptors

4 and 5. Appropriate system and effect on heart rate both needed

4 max

[6]

Q10.

- (a) 1. (Usually) Type II produce insulin;
2. Cells / receptors less sensitive / responsive (to insulin)
- OR**
3. Faulty (insulin) receptors;
(Treated / controlled by) diet / exercise;
2. *Accept: cells / receptors do not respond.*
 2. *Accept: 'fewer receptors'*
 3. *Accept: (Treated / controlled by) weight loss / medication / drugs.*
 3. *Ignore: diabetes is caused by diet / exercise.*

2 max

- (b) Tick in box 4

- (c) 1. Attach to gene / DNA / promoter region;
 2. Stimulate / inhibit transcription / RNA polymerase;
Note: Genes being expressed / inhibited or switched on / off is not enough on its own.

2

- (d) 1. (Effective as) group A / with iPS / treated lower than group B / with diabetes;
 2. (Effective as) group A similar to group C / without diabetes;
 3. (Investigation) done on mice not humans;
 4. Only shows results for 12 weeks / short-time period / long-term effects not known;
Ignore: Only one study / not repeated / sample size.
 2. Accept: 'healthy' or 'normal' or control for group C.

4

[9]

Q11.

- (a) (Formation of glycogen)

1. Glucose concentration in cell / liver falls below that in blood (plasma) which creates / maintains glucose concentration / diffusion gradient;
 2. Glucose enters cell / leaves blood by facilitated diffusion / via carrier(protein) / channel (protein);
Not just diffusion

2

- (b) 1. Insulin sensitivity similar to / not (significantly) different from those with diabetes;
No values for non-obese, so comparisons with 'normal' not possible
 2. Overlap of SDs;
Accept SE
 3. Their sensitivity (to insulin also) improved by GBS;

2 max

- (c) 1. Sensitivity (to insulin) does increase;
This part of the question concerns spread of data, not overlap of SDs
 2. But large SD / large variation (after GBS);
Accept use of figures / use of SD values to make this point.
Ignore ref to SE
 3. (So) some showing no / little change / get worse;
 4. Do not know what sensitivity to insulin is of non-diabetics (who are not obese);
Accept 'normal' as non-diabetic

3 max

[7]

Q12.

- (a) 1. Positive correlation between sucrose and dopamine concentrations / higher concentration of sucrose, more dopamine;

Q NB question is 'How do these ...', not 'Do these

1. Ignore simple statements of numbers from graph without description of trend

2. So (dopamine) makes them want to drink / eat more (sucrose);
3. Positive feedback because drinking / eating leads to wanting to drink / eat (even) more;

3. It must be a clear statement of why this example is positive feedback, not inferred from points 1 and 2

3

- (b) 1. (Refractory period) leads to discrete / separate nerve impulses / time when another nerve impulse can't happen;

OR

(Refractory period) limits number of impulses per second / frequency of nerve impulses;

2. When maximum frequency reached / exceeded, no further increase in information / all (higher) concentrations of sucrose seem the same;

2

- (c) 1. (Negative feedback) stops desire / wish to eat / appetite;

1. Accept stops dopamine release (in this context)

1. Accept makes them feel full

2. (This) limits amount eaten / stops eating;

2. Accept prevents constant eating

3. Prevents / reduces risk of obesity / too much energy intake;

3. Accept prevents vomiting

Accept descriptions based on what would happen in absence of the feedback mechanism - or if stomach empty for points 1 and 2

3

[8]

Q13.

- (a) 1. Glucose oxidase and peroxidase;

Both enzymes required

2. Dye (with colour A);

Reject 'dye with colour B'. Ignore named dyes

2

- (b) 1. Concentration is given as a range (for each colour) / measurement is not precise;

2. Only measures glucose concentration above normal / above 170 (mg 100 cm⁻³) (in blood);

3. 170 (mg 100 cm⁻³) is an average figure / concentration for loss to urine

varies (between people);

4. Difficult to match colour against chart / colour match is subjective;

2 max

[4]

Q14.

- (a) Treatment requires person receiving insulin (in some way);

Accept descriptions e.g. insulin injection

Reward idea that insulin must be received, not that it isn't being produced

1

- (b) 1. No / fewer / abnormal receptors on (cell) membrane;

2. (So) fewer (glucose) transport proteins;

3. (So) less glucose can enter (cells);

4. (So) less glucose converted to glycogen;

Accept no / fewer enzymes (for this conversion) are activated

5. (So, without treatment) blood glucose concentration not lowered when high / above normal;

Accept converse

3 max

- (c) 1. Movement uses muscles;

2. Movement increases (rate of) respiration;

3. Respiration uses glucose / respiration reduces blood glucose concentration;

2 max

- (d) 1. Identification of 195 ± 2 and 113 ± 2 ;

2. Answer within range of 1.67 to 1.77 (times greater);

Ignore numbers after two decimal places

Correct answer = 2 marks

2

- (e) 1. Meal / uncontrolled intake v 75 g glucose / controlled intake;

Must have both sides of the story for each point. Marking guidance shows researcher's method first

Idea of could eat anything in meal as against just glucose

2. (Concentration) measured over 6 hours / 6+ hours / longer v measured at 2 hours;

3. (After intake) regular monitoring / several measurements v only measured once / at 2 hours only;

4. No fasting v fasting before test;

Credit other descriptions of fasting e.g. went without food as opposed to didn't have to

5. Not (necessarily) at rest v remained at rest;
6. Tested during afternoon v tested in morning;
Accept idea of tested at different times of the day

3 max

- (f)
1. Pre-diabetics are at risk of developing diabetes / some pre-diabetics reach a concentration of 180 (mg 100 cm⁻³) after a meal;
 2. Some pre-diabetics will now be classed as diabetic;
 3. Detection leads to treatment (sooner);
 4. Diabetes damages the body / is life-threatening;
Accept examples of damage e.g. blindness, heart disease

3 max

[14]

Q15.

1. Diabetics have (blood glucose) concentration greater than 140 mg cm⁻³ / than her estimate / estimate suggests she is pre-diabetic;
2. Colour change is subjective / blood on test strip masks colour change;
3. Concentration given as a range / estimation is not reliable;
4. May not have fasted;
5. May not have had a drink with 75 g glucose;
6. Only one test carried out;
No mark for valid or not valid

[3]

Q16.

- (a)
1. Adenylate cyclase activated / cAMP produced / second messenger produced;
 2. Activates enzyme(s) (in cell so) glycogenolysis / gluconeogenesis occurs / glycogenesis inhibited;
2. Neutral: 'glucose produced' as given in the question stem
Accept: correct descriptions of these terms

2

- (b) (i)
1. Glucose / sugar in food would affect the results;
1. Accept references to starch / carbohydrate
Or
 2. Food / eating would affect blood glucose (level);
Or
 3. (Allows time for) blood glucose (level) to return to normal;
3. Neutral: allows time for insulin to act

1 max

- (ii)
- Type 2 diabetes is a failure to respond to insulin / still produces insulin / is not insulin-dependent;

(iii) (For) – 3 max

A maximum of three marks can be awarded for each side of the argument

1. Avoids injections / pain of injections;
2. Long(er) lasting / permanent / (new) cells will contain / express gene;
Ignore references to methodology e.g. sample size not known
3. Less need to measure blood sugar / avoids the highs and lows in blood sugar;
4. Less restriction on diet;

(Against) – 3 max

5. Rats are different to humans;
6. May have side effects on humans;
6. Accept: virus may be harmful / disrupt genes / cause cancer
7. Long(er) term effects (of treatment) not known / may have caused effects after 8 months;
8. (Substitute) insulin may be rejected by the body;

4 max

[8]

Q17.

(a) Enzyme / active site has a (specific) tertiary structure;

Only glucose has correct shape / is complementary / will bind / fit to active site;

(Forming) enzyme-substrate complex;

Q Allow second mark if candidate refers to correct shape or complementary in terms of the enzyme. Do not allow 'same' shape

Q Do not allow third mark if active site is described as being on substrate.

3

(b) (Only detects glucose whereas) Benedict's detects (all) reducing sugars / named examples;

Provides a reading / is quantitative / Benedict's only provides a colour / doesn't measure concentration / is qualitative / semiquantitative;

Is more sensitive / detects low concentration;

Red colour / colour of blood masks result;

Can monitor blood glucose concentration continuously;

Q Do not credit quicker / more accurate unless qualified.

Q Allow Benedict's detects monosaccharides for first mark point.

2 max

(c) (i) Broken down by enzymes / digested / denatured (by pH) too large to be absorbed;

1

(ii) Study not carried out on humans / only carried out on rats;
Long-term / side effects not known;
Scientists have vested interest;
Study should be repeated / further studies / sample size not known;

2 max

[8]

Q18.

(a) (i) Glucose;

Fructose;

Any order.

2

(ii) Lactose has a different shape / structure;

Does not fit / bind to active site of enzyme / sucrase;

Only allow a second mark if reference is made to the active site.

Max 1 mark if active site is described as being on the substrate.

OR

Active site of enzyme / sucrase has a specific shape / structure; Does not fit / bind to lactose;

Do not accept same shape.

2

(b) (i) Rose and fell;

Peak at 45 (minutes) / concentration of 6.6 (mmol dm⁻³);

2

(ii) Glucose (produced by digestion) is absorbed / enters blood;

Decrease as used up / stored;

2

[8]

Q19.

(a) Hydrostatic pressure / description of pressure / description of how pressure generated;
Causes ultrafiltration (*Allow description of ultrafiltration*) at Bowman's capsule / glomeruli / renal capsule;
Through basement membrane;
Enabled by small size urea molecule;

2 max

(b) Reabsorption of water / by osmosis;

At the PCT / descending LoH;
At the DCT / CD;
Active transport of ions / glucose creates gradient (in context);
Ignore references to facilitated diffusion or to selective reabsorption.

3 max

[5]

Q20.

- (a)
1. Blood pressure / hydrostatic pressure;
 2. Small molecules / named example;
 3. Pass through basement membrane / basement membrane acts as filter;
 4. Protein too large to go through / large so stays behind;
 5. Presence of pores in capillaries / presence of podocytes;

5

- (b)
1. High concentration of glucose in blood;
 2. High concentration in tubule / in filtrate;
 3. Reabsorbed by facilitated diffusion / active transport;
 4. Requires proteins / carriers;
 5. These are working at maximum rate / are saturated;
 6. Not all glucose is reabsorbed / some is lost in urine;

4 max

- (c) For general principle, applied to either example:

1. More water (from filtrate) reabsorbed / returned to blood / less lost in urine;
2. By osmosis;
3. From collecting duct / from end of second convoluted tubule;
4. Due to longer loop of Henle;

For loop of Henle, maximum 2 marks:

5. Sodium / chloride ions absorbed from filtrate in ascending limb;
6. Gradient established in medulla / concentration of ions increases down medulla;

For ADH, maximum 2 marks:

7. Acts on collecting duct / distal convoluted tubule / second convoluted tubule;
8. Makes cells more permeable / inserts aquaporins in plasma membranes;

Note: to score full marks, candidates must make one specific statement about Loop of Henle and one about ADH.

6 max

[15]

Q21.

- (a) In Diabetic person:

1. Lack of insulin / reduced sensitivity of cells to insulin;
2. Reduced uptake of glucose by cells / liver / muscles;
3. Reduced conversion of glucose to glycogen;

*Penalise zero / no
once only*

3

- (b) (i) Leaves the blood at kidney;
Taken back into blood / reabsorbed (from kidney tubule);
Reject some reabsorption
- (Reabsorbed) in 1st convoluted tubule;
Kidney / named part needs to be mentioned once
- 2 max
- (ii) Large amount / high concentration of glucose in filtrate;
Cannot all be reabsorbed / 1st convoluted tube too short to reabsorb
all of glucose / saturation of carriers;
- 2
- (c) Enzyme has specific shape to active site / active site has specific tertiary
structure;
Only glucose fits / has complementary structure / can form ES complex;
- 2
- (d) Glucose in filtrate lowers water potential;
Ignore 'urine'. Accept increase solute potential
- Lower Ψ gradient / less difference in Ψ filtrate – Ψ plasma;
Ignore 'concentration'
- Less water reabsorbed by osmosis;
*Accept diffusion of water. Reject no water reabsorbed if
implied*
- 3
- (e) 1. Glomerulus / Bowman's capsule / renal capsule;
2. Basement membrane;
3. Proteins are large (molecules) / proteins cannot normally pass through
filter / proteins
can only pass through if filter damaged;
- 3

[15]

Q22.

- metabolic water / from respiration;
allow condensation reactions. Ignore 'oxidation'.
- aerobic / use of oxygen; ('From aerobic respiration' = 2 marks)

[2]

Q23.

- (a) Lower volume AND higher concentration;
ADH increases water re-absorption (in 2nd convoluted tubule / collecting duct) /
increases water permeability / adds aqua porous;

Evidence: observe increasing concentration (of dissolved substances) (in 2nd
convoluted tubule / collecting duct) / concentration increased c.f. ADH absent

Once only for full marks

3

- (b) Protein molecule too large (to cross filter in healthy person);
Protein can cross if filter is damaged / protein from damaged glomerulus
enters filtrate;

Q24.

- (a) On graph: X where glucose level is below norm
AND Y where glucose level is above norm;

1

- (b) EITHER

1. Use m-RNA + reverse transcriptase to produce gene / (c)-DNA;
2. Restriction enzyme to cut open plasmid;
3. Add sticky ends (to insulin gene and to plasmid);

OR Allow:

1. Cut out insulin gene / cut open plasmid with restriction enzyme;
2. Use same restriction enzyme on second DNA;
3. Reference to (complementary) sticky ends;
4. Use ligase to join 2 DNA molecules;
5. Modified plasmid taken up by bacteria;

max 4

[5]

Q25.

- (a) (i) glucagon;

Insist on spelling

1

- (ii) liver;

1

- (b) A change to the normal level initiates a response which reduces the effect / reverses / acts against the change;

1

[3]

Q26.

- (a) any two named polymers [subsets = 1 max. (e.g. protein / haemoglobin)]

2

- (b) (i) hydrostatic pressure / description of pressure;
causes ultrafiltration at Bowman's capsule / glomeruli / renal capsule;
through basement membrane;
enabled by small size of urea molecule;

max 2

- (ii) reabsorption of water; [water out]
by osmosis;
at the PCT / descending LoH;
at the DCT / CD;
active transport of ions / glucose creates gradient (in context);

max 4

- (c) (i) by (simple) diffusion;

[reject facilitated]

1

- (ii) to maintain concentration gradients / stop reaching equilibrium;
[idea of maintaining concentration gradients]

- (iii) ions, glucose and amino acids would diffuse into the dialysate;
because of their concentration gradients;
Causing deficiency in these substances;

OR

the WP of the dialysate would be higher / less negative than the WP of the surrounding tissues;
therefore osmosis would take place into the cells surrounding the abdominal cavity;
causing these cells to burst / damaging these cells / cannot be excreted;

max 2

[12]

Q27.

- (a) Pituitary;

Ignore any reference to lobe / hypothalamus.

1

- (b) (i) (Each) protein has a tertiary structure;
Gives specific / correct shape / size to (inside of) channel / pore;

2

- (ii) More negative / lower WP (inside tubule cells);
accept Ψ symbol / down a WP gradient

Water enters / moves by diffusion / osmosis;
ignore water concentration, etc.

2

[5]

Q28.

- (a) ADH;

Accept vasopressin

1

- (b) Reabsorption / passes back into blood / tissue fluid;

1

By active transport;

1

- (c) (sodium) ions pumped out of ascending limb;

1

Water passes out of descending limb (into high concentration in tissue fluid / interstitial fluid);

1

Some sodium ions re-enter descending loop (by diffusion);

1

High concentration at base of loop / some ions diffuse out near base increasing concentration outside loop;

3 max

1

Q29.

(a) (i) Renal capsule / Bowman's capsule / glomerulus / basement membrane;

1

(ii) blood cells / platelets / proteins / named plasma protein;

1

(b) 75 divided by 60 / 75 divided by 0.01;

1

Answer 125;

(Correct answer gains two marks)

1

(c) (Many) mitochondria provide ATP / energy for active transport;
(Many) carrier proteins for active transport / channel proteins for facilitated diffusion;
Microvilli / brush border provide large surface area (for absorption);

2 max