A2.3 **HOMEOSTASIS**

ANSWERS & MARK SCHEMES

QUESTIONSHEET 1

a) (i) the internal conditions of the body;
such as body temperature/blood pH/blood salt concentration/blood osmotic pressure; **2**

(ii) negative feedback control is when a varying physiological value is returned to its mean value by the controlling mechanism (credit example. eg. sweating to reduce body temperature);
positive feedback control is when a physiological value is pushed above its mean value by the controlling mechanism (credit example eg. increased uterine contractions in birth); **2**

(iii) -ve : normal body temperature/blood pressure/blood osmotic pressure/blood pH/ventilation rate/any correct eg;
+ve : oxytocin release during birth/oxytocin release in suckling/body temperature during fever/any correct eg; **2**

(iv) the reduction or suppression of a feedback control mechanism when the required physiological value is reached;
(usually feedback control mechanisms are not completely turned off) **1**

(b) Amoeba: osmoregulation/water removal by the contractile vacuole;
Marram grass: water loss from leaves by hinge cells closing stomata/rolling leaf up;
Human: control of blood pressure/blood osmotic pressure/blood salt and water concentration by ADH mechanism /any other valid examples; **3**

TOTAL 10

QUESTIONSHEET 2

(a) thermoreceptors in skin sense surface/shell temperature;
thermoreceptors in hypothalamus sense core/blood temperature;
relay nerve impulses to heat gain/heat loss/thermoregulatory centres in hypothalamus; **3**

(b) baroreceptors sense blood pressure;
situated in walls of arterial arches/bases of great veins/aortic and carotid bodies;
relay nerve impulses to vasomotor centre in brain/medulla (to regulate cardiac output/blood pressure); **3**

(c) glucoreceptors sense blood glucose concentrations;
situated on cell membranes of alpha and beta cells of the islets of Langerhans;
if blood glucose concentration rises beta cells stimulated to release insulin to lower it
/if blood glucose concentration falls alpha cells stimulated to release glucagon to raise it; **3**

(d) proprioceptors are tension and pressure receptors;
situated in muscles and tendons/ ligaments/joint capsules;
send nerve impulses to cerebellum to regulate muscle tone/enable balance/coordinated movements; **3**

TOTAL 12

QUESTIONSHEET 3

(a) (i) low/decreasing value as it used up/fasting blood glucose concentration;
value is not obscured by absorption of glucose from gut to blood; **2**

(ii) 4.2 millimoles dm^{-3}; (allow range 4.1 to 4.3) **1**

(b) A-B: glucose being absorbed from gut (into blood stream);
faster than it is being converted to glycogen;
and stored in liver/muscles;
under the influence of insulin; **max 3**

B-C: glucose absorption from gut to blood is reducing/stopping;
β-cells release more insulin;
α-cells release less glucagon;
conversion to glycogen for storage is faster than absorption; **max 3**

TOTAL 9

QUESTIONSHEET 4

(a) (i) regulators are organisms that regulate or control their physiological values within narrow limits;
any one of: mammals/birds/flowering plants/specific example of these;
non regulators do not control their physiological values within narrow limits;
any one of: cnidarians/algae/specific example of these; **4**
(most other organisms are regulators for some values and non regulators for other values)

(ii) exogenous rhythms are those that are related to regular changes in environmental stimuli;
eg. heart rate /blood pressure;
endogenous rhythms are those that follow a spontaneous internal cycle; **4**
eg. core temperature/sleep patterns;

(b) metabolism out of phase;
due to crossing time zones;
thus may need to be awake when body clock thinks it is time to sleep/body clock confused/ref body clock;
ref. to melatonin; **4**

TOTAL 12

QUESTIONSHEET 5

negative feedback;
hypothalamus;
osmolality/osmotic pressure/sodium ion concentration;
<u>posterior</u> pituitary body;
neurosecretion;
collecting duct;
water permeable;
reabsorbed;

TOTAL 8

QUESTIONSHEET 6

Action	Hormone
Breakdown of glycogen in the liver	glucagon/adrenaline;
Non shivering thermogenesis	adrenaline;
Lowering of blood glucose concentration	insulin;
Acceleration of heart beat	adrenaline/thyroxine;
Reduction of water loss in urine	antidiuretic hormone;
Increase in flow of gastric juice	gastrin;
Increase in antibody release by plasma cells	interleukin;

TOTAL 7

QUESTIONSHEET 7

(a) (i) so that water content of body is maintained at constant level/no dehydration/ no over dilution;
so that blood concentration/osmotic pressure/volume/blood pressure can be kept constant; **2**

(ii) l: sweat;
due to temperature rise and so more secretion of sweat to cool body (using latent heat); **2**

2: respiration;
more energy required so faster respiration thus more metabolic water released; **2**
(exhaled air; more respiration thus more gas exchange thus more water lost by evaporation;)

(iii) more water loss by increased sweating;
thus rise in blood concentration sensed by osmoreceptors (in hypothalamus);
thus ADH secretion stimulated and more water reabsorbed from urine in collecting ducts (to blood); **3**

(b) osmoreceptors in hypothalamus;
sense when blood is too concentrated or too dilute;
if too concentrated ADH release from posterior pituitary is stimulated;
ADH in blood causes collecting tubule walls to become water permeable;
so that water is reabsorbed from urine;
high salt concentration in renal medulla (which results from counter current mechanism) enhances water reabsorption; **max 5**
(allow converse points about ADH not released as alternative scheme)

TOTAL 14

QUESTIONSHEET 8

(a) Any four of:
diabetes insipidus is a failure of ADH production/by the <u>posterior</u> pituitary/
thus excessive diuresis/water loss through urine occurs (resulting in dehydration/death)/
diabetes mellitus is a failure of the beta cells in the islets (of Langerhans) to produce insulin/
thus insufficient blood glucose is converted to glycogen and glucose is lost in urine;;;; **4**

(b) homeostasis is the regulation of the internal environment within narrow limits;
using negative and positive feedback mechanisms;
haemostasis is the stopping of bleeding after tissue damage;
enabled by the blood platelets/clotting cascade mechanism; **4**

(c) diuresis is the loss of water in urine;
regulated by antidiuretic hormone;
deamination is the removal of (toxic) amine groups from unwanted amino acids;
occurs in the liver/ornithine cycle to make urea (for excretion); **4**

TOTAL 12

QUESTIONSHEET 9

(a) osmoregulation/to control Amoeba's water content; **1**

(b) collects excess water from cytoplasm using energy from ATP;
when vacuole is full it bursts at the cell membrane releasing water to exterior; **2**

(c) water enters Amoeba along concentration gradient between external and internal environments;
in pure water cytoplasm is most hypertonic to exterior and so most water enters and so vacuole has to work harder;
as cytoplasm becomes less hypertonic to exterior less water enters and so vacuole works less;
at 70% seawater cytoplasm is isotonic to sea water and so osmotic entry and loss of water are the same and so vacuole need not operate;
(IOB recommends that the terms 'water potential' and 'solute potential' are not applied to animals) **4**

TOTAL 7

QUESTIONSHEET 10

(a) (i) ascending limb of loop of Henle is always impermeable to water;
but has a very powerful active transport mechanism for pumping Na^+/Cl^- out of tubule (into interstitial fluid);
this lowers the concentration as tubular fluid rises up ascending limb;
$Na^+/C1^-$ diffuse into descending limb (from higher concentration in surrounding interstitial fluid);
raising concentration of tubular fluid as it passes down the decending limb; **max 4**

(ii) maintains a high salt concentration in the medulla/interstitial fluid;
this enables water reabsorption from the collecting ducts (when ADH is present); **2**

(iii) maintains blood salt concentration;
and so helps to maintain blood osmotic pressure/blood pressure; **2**

(b) ADH: renders the collecting duct walls permeable to water;
so that water may be reabsorbed or lost thus regulating blood volume/ pressure/concentration; **2**

Aldosterone: stimulates uptake of Na^+ by active transport;
from ascending limb of loop of Henle (thus retains body sodium ions);
stimulates active secretion of K^+ ;
into distal convoluted tubule (thus lowering body potassium ion content); **max 3**

TOTAL 13

QUESTIONSHEET 11

(a) (i) when for instance, blood volume varies above or below its norm;
a mechanism is operated to bring the varying value back to the norm; **2**

(ii) when a mechanism has operated to bring a value back to the norm, the mechanism activity is reduced (but not totally switched off); **1**

(iii) when a hormone is secreted as a result of nervous stimulation; **1**

(b) (i) in the midbrain/just behind the pituitary body; **1**

(ii) to regulate physiological functions in general - such as sleep/body temperature/blood osmolality/any other valid example; **1**

(c) Any four of:
increased blood pressure increases glomerular blood pressure/
increases ultrafiltration/
thus a larger volume of glomerular filtrate is formed (per unit time)/
raised blood pressure inhibits ADH release/
thus collecting ducts become impermeable to water/
thus no water reabsorbed from urine so urine volume increases;;;; **4**

TOTAL 10

QUESTIONSHEET 12

(a) (i) A = renal artery; B = ureters; C =urethra; D = dorsal aorta; **4**

(ii) male urethra is much longer (since it extends through the penis); **1**

(b) 1. removal of toxic waste products from blood/excretion;

2. regulation of blood pH/osmolality/pressure/ref homoeostasis of body fluids; **2**

(c) to prevent urination/micturition until a convenient time/prevents constant dribbling of urine from bladder/keeps bladder closed to reduce infection risk; **1**

TOTAL 8

QUESTIONSHEET 13

(a) C; (b) B; (c) A; (d) B;

TOTAL 4

QUESTIONSHEET 14

(a) 60 x 120; = 7200 cm^3 or 7.2 dm^3; (units essential) **2**

(b) 125 x 60 x 24; = 180000 cm^3 or 180 dm^3; (units essential) **2**

(c) $\frac{180}{7.2}$; = 25; **2**

(d) Any three of:
about 80% / much of the water is reabsorbed back to blood/
in the proximal convoluted tubule/
more water is reabsorbed via the collecting ducts/
in the presence of ADH;;; **3**

TOTAL 9

QUESTIONSHEET 15

(a) (i) A = glomerulus;
B = renal/Bowman's capsule;
C = proximal/first convoluted tubule;
D = descending limb (of loop of Henle);
E = ascending limb (of loop of Henle);
F = distal/second convoluted tubule;
G = collecting duct; **7**

(ii) C is very permeable to water;
E is never permeable to water;
G is only water permeable if ADH is present; **3**

(b) (i) Any two of:
glucose/amino acids/(some) urea;; **2**

(ii) Any two of:
hydrogen ions/potassium ions/creatinine/hydrogen carbonate ions/ammonia;; **2**

(c) (i) to achieve a high salt concentration in the medulla of the kidney/ around the collecting ducts;
so that water may be reabsorbed osmotically from urine in collecting ducts (in presence of ADH); **2**

(ii) Any two of:
ADH release is suppressed when blood volume/pressure is too high/ blood concentration too dilute/
ADH increases permeability of collecting ducts to water/
thus in absence of ADH water is not reabsorbed;; **2**

TOTAL 18

QUESTIONSHEET 16

(a) ureter carries urine from kidney to bladder;
urethra carries urine from bladder to exterior;
ureter lined by a transitional epithelium;
urethra lined by compound/stratified squamous epithelium; **4**

(b) urinary bladder stores urine until a suitable time for release;
gall bladder stores bile (from liver) until food enters duodenum;
urinary bladder situated in pelvis/just ventral to rectum/lined by transitional epithelium;
gall bladder lies near liver/lined by columnar epithelium; **4**

(c) glomerulus is a knot of capillaries situated in the renal capsule;
vasa recti form a network of capillaries over the nephron tubules;
glomerulus is concerned with ultrafiltration/forming glomerular filtrate;
vasa recti are concerned with exchange of materials between tubular fluid and blood; **4**

(d) afferent arteriole carries blood from renal/arcuate artery branch to glomerulus;
efferent arteriole carries blood from glomerulus to vasa recti;
efferent arteriole narrower than afferent arteriole (so that blood pressure in the glomerulus is raised);
blood in efferent arteriole has reduced urea/glucose/salt/amino acid (or any other valid substance)
concentrations compared to afferent arteriole blood; **4**

TOTAL 16

QUESTIONSHEET 17

high; renal artery; glomeruli; renal/Bowman's; ultrafiltration/high pressure; proteins; osmotic pressure;
urea/uric acid/ammonia or any other; glucose;

TOTAL 9

QUESTIONSHEET 18

(a) have many mitochondria to produce much ATP;
required as energy supply for large amount of active transport carried out (by these cells);
allowing reabsorption of glucose/some amino acids/ some salts/ some urea;
microvilli increase surface area available for reabsorption; **4**

(b) podocytes are epithelium/pavement cells;
which are raised off their basement membrane;
thus the cavities of the glomerular capillaries and renal capsule are only separated by the basement membranes;
this increases the efficiency of transport into the capsules of small molecules from the blood plasma/increases the efficiency of ultra filtration; **3**

(c) coffee contains caffeine;
caffeine inhibits the release of ADH;
thus no water can be reabsorbed by collecting ducts from urine; **3**

TOTAL 10

QUESTIONSHEET 19

(a) the regulation of the internal environment within narrow limits;
thus making it independent of the external environment; **2**

(b) (i) Any three of:
in freshwater, water enters the Amoeba by osmosis/
this water is collected into the contractile vacuole and expelled/
by an active/energy requiring process/thus maintains the osmotic concentration of Amoeba's cytoplasm/prevents bursting;;; **3**

(ii) desert animals must conserve water since little is available;
long loop of Henle means more salt is pumped out of loop into medulla of kidney;
thus allows more water to be reabsorbed from collecting ducts (if ADH is present); **3**
(reject more water would be reabsorbed through the loop of Henle - it is impermeable to water)

(iii) insect are small and mainly land animals/thus tend to lose water through their relatively large surface areas;
uric acid is virtually insoluble in water;
thus insect Malpighian tubules produce it to enable excretion of solid urine/so preventing water loss; **3**

(c) (i) diabetes insipidus; **1**

(ii) failure to synthesise ADH in the <u>posterior</u> pituitary gland; **1**

TOTAL 13

QUESTIONSHEET 20

Feature	GF	Urine	
Contains glucose	✓	✗	;
Does not contain amino acids	✗	✗	; (about 2 g of amino acids are
Has a pH of 3.5	✗	✗	; excreted per day as amino acids)
Same composition of blood	✗	✗	;
Never contains protein	✓	✓	; **TOTAL 5**

QUESTIONSHEET 21

(a) by blood buffering systems;
such as haemoglobin/phosphate/ hydrogen carbonate/protein buffering systems; **2**

by control of ventilation/inspiration and expiration rate;
which regulates the H^+ and HCO_3^- concentrations in blood plasma; **2**

(b) many hydrogen ions pass from plasma to glomerular filtrate during ultrafiltration (thus raising blood pH);
hydrogen ions are actively secreted from blood into the distal convoluted tubules (also raising blood pH);
but this lowers pH of tubular fluid;
around pH 4.8 the active transport pumps can no longer force more H^+ into the tubule;
therefore distal tubule cells also actively secrete ammonia/NH_3 into tubule;
this combines with H^+ and Cl^- to make ammonium chloride (credit equation);
buffering the urine pH (to pH 6.0); **max 5**

TOTAL 9

QUESTIONSHEET 22

(a) (i) volume smaller/has passed through a filter; **1**

(ii) more water is reabsorbed in collecting duct (in the presence of ADH); **1**

(b) (i) blood urea passes freely from A to B during glomerular filtration;
higher concentration at C due to water reabsorption reducing the volume of tubular fluid in proximal convoluted tubule;
even more water reabsorption in F causes further concentration of urea in urine; **3**

(ii) from C to D as tubular fluid passes down into higher salt concentrations of medulla, salt diffuses into the tubule raising the concentration;
from D to E active transport pumps salt out of tubule into surrounding interstitial fluid;
thus concentration of salt falls in tubular fluid from D to E: **3**

(iii) proteins are large molecules/high molecular weight;
cannot cross membranes separating glomerular blood and capsule fluid/substances with a molecular weight greater than 65,000 cannot cross filter; **2**

(iv) all glucose actively reabsorbed in proximal convoluted tubule; **1**

TOTAL 11

QUESTIONSHEET 23

(a) (i) false;
the kidneys are concerned with the regulation of blood and other body fluids, (this results in urine formation);
the kidneys are concerned with excretion of toxic metabolic waste products, (this also results in urine formation); **3**

(ii) false;
on a hot day more water is lost from blood by sweating;
thus blood volume falls/blood concentration rises and ADH release is stimulated causing water reabsorption from urine in collecting ducts; **3**

(iii) true;
uric acid is insoluble and so does not poison the embryo in the closed environment of the egg;
also can be excreted as solid urine thus conserving water; **3**

(b) (i) Any three of:
dialysis is the separation of large molecules from small molecules/
across a differentially permeable membrane/
principle used in kidney machine/haemodialysis/peritoneal dialysis/
to remove toxic waste products from patient with kidney failure;;; **3**

(ii) in incurable/irreversible kidney damage/patients on long term dialysis;
when a kidney becomes available, usually from a recently dead donor/car accident victim;
tissue antigens/ref HLA antigens of donor kidney and recipient must be close matching to avoid rejection problems; **3**

TOTAL 15