A2.1 **METABOLIC PATHWAYS**

ANSWERS & MARK SCHEMES

QUESTIONSHEET 1

(a) cytoplasm; **1**

(b) (i) glucose activated by addition of phosphate/by ATP;
therefore intermediate B is at a higher energy level; **2**

(ii) energy taken from B and C;
trapped on ATP/NADH; **2**

(c) enters mitochondrion;
converted to acetylcoenzyme A; **2**

(d) Any three of:
NAD/FAD/
receive electrons / H^+/ are reduced/
coenzymes are reoxidised in the electron transport chain/
generating ATP/
by oxidative phosphorylation;;; **3**

TOTAL 10

QUESTIONSHEET 2

(a) (i) adenine; **1**

(ii) ribose; **1**

(b) (i) intermediate position;
means that they can accept or donate (energy rich) phosphate; **2**

(ii) Any two of:
(very) high energy content/
allows rapid/sudden contraction/
since ATP synthesis is relatively slow;; **2**

TOTAL 6

QUESTIONSHEET 3

Statement	ATP production in		
	Chloroplast	Mitochondrion	
Electrons are excited by photons	✓	✗	;
Electrons pass through carriers	✓	✓	;
Involves oxidative photophosphorylation	✓	✗	;
ATP produced from ADP and phosphate	✓	✓	;
Occurs in day and night	✗	✓	;

TOTAL 5

QUESTIONSHEET 4

(a) X pyruvate/acetyl coenzyme A;
Y CO_2; **2**

(b) (i) matrix of mitochondrion; **1**

(ii) cristae/inner membrane of mitochondria; **1**

(c) carriers are alternately reduced and oxidised;
gain of electrons/hydrogen = reduction/loss of electrons/hydrogen = oxidation;
linked to ATP synthesis/oxidative phosphorylation; **3**

(d) cyanide stops the flow of electrons/blocks the electron transport chain/blocks cytochrome oxidase;
prevents regeneration of NAD/FAD from NADH/FADH or prevents reoxidation of NADH/FADH/cytochromes;
thus ATP synthesis is inhibited; **max 2**

TOTAL 9

QUESTIONSHEET 5

(a) X ATP;
Y CO_2/hydrogen/H; **2**

(b) glycolysis in cytoplasm;
Krebs in matrix of mitochondria; **2**

(c) high levels of ATP;
inhibit conversion of intermediate 1 to intermediate 2;
prevents excess production of ATP; **3**

TOTAL 7

QUESTIONSHEET 6

(a) cytoplasm; **1**

(b) provides activation energy/makes glucose more reactive; **1**

(c) dehydrogenation/oxidation/redox reaction/(if say reduction must specify NAD $\rightarrow$ NADH); **1**

(d) (i) hydrogen from NADH used to reduce pyruvate to lactate;
(ii) hydrogen from NADH used to reduce pyuvate to ethanol; **2**

(e) hydrogen/electrons removed from substrate/intermediate/named intermediate;
reference to carriers/NAD/FAD;
passed to successively lower energy levels;
energy released used to convert ADP into ATP/ phosphorylate ADP; **max 3**

TOTAL 8

QUESTIONSHEET 7

Stage	Site	Oxygen Needed?	What Happens?
Glycolysis	**Cytoplasm;**	**No;**	Glucose is converted to **pyruvic acid**; Hydrogen is removed and is passed to the electron carriers.
Link Reaction;	Matrix of Mitochondria	Yes	Pyruvate enters mitochondrion, is decarboxylated, dehydrogenated and combines with coenzyme A to give acetyl coenzyme A. The hydrogen which is removed is passed to the electron carriers.
Kreb's Cycle;	**Matrix of Mitochondria;**	**Yes;**	A cyclical series of reactions during which hydrogen is passed to the electron carriers, carbon dioxide is removed and a starting reactant is regenerated.
Electron Transfer Class	**Crista/Inner Membrane of Mitochondria;**	Yes	The hydrogen from the respiratory reactions is split to release electrons. These pass through carriers and generate **ATP**;. The hydrogen reforms and is combined with oxygen to release water.

TOTAL 9

QUESTIONSHEET 8

(a) Any three of:
glucose phosphorylated/activated/
using ATP/
split into 3C/triose phosphate/
oxidation/dehydrogenation of trioses yields pyruvate;;; **3**

(b) (i) cytoplasm; **1**

(ii) matrix of mitochondria; **1**

(c) Any three of:
ATP binds to enzyme/isocitrate dehydrogenase/
at a site other than the active site/
this changes the shape of the enzyme/active site/
therefore substrate cannot attach and process slowed/
this happens when too much ATP has been made;;; **3**

(d) Any three of:
pyruvate decarboxylated to ethanal/
producing carbon dioxide/
ethanal converted/reduced to ethanol/
enabling NADH to be oxidised to NAD;;; **4**

TOTAL 12

QUESTIONSHEET 9

(a) Any three of:
overwatering leads to anaerobic condition/
anaerobic conditions inhibit electron transport chain/
thus pyruvic acid/pyruvate has been converted into ethanol/
to enable NADH to be reoxidised to NAD; **3**

(b) Any two of:
acetyl coenzyme A can be formed from other substrates/
from breakdown of fats/
from deamination of amino acids;; **2**

(c) Any four of:
oxygen supply to muscles is inadequate during severe exercise/
thus electron transport system inhibited/
thus NADH cannot be reoxidised/
pyruvic acid converted to lactic acid/
changing NADH back to NAD;;;; **4**

TOTAL 9

QUESTIONSHEET 10

(a) (i) lactate/lactic acid;
(ii) carbon dioxide;
(iii) electrons/hydrogen;[reject H_2] **3**

(b) (i) adds phosphate to ADP to produce ATP;
(ii) remove hydrogen from substrates/oxidise substrates/pass hydrogen to acceptors; **2**

(c) without oxygen there is no final acceptor for electrons/hydrogen from electron transport chain;
hence no regeneration /reoxidation of coenzymes;
thus Krebs cycle stops;
electron transport chain and Krebs cycle provide most of the ATP; **4**

TOTAL 9

QUESTIONSHEET 11

(a) (i) organic molecules necessary for enzyme function;
not permanently attached to the enzyme;
involved in transfer of hydrogen/electrons/acetate groups/energy/any other correct example; **max 2**

(ii) similar to coenzyme but tightly bound to one specific enzyme; **1**

(b) vitamin B complex/nicotinic acid/riboflavin is required for synthesis of NAD/FAD;
pantothenic acid/coenzyme A required to produce acetyl CoA from pyruvate;
less acetyl CoA means less substrate for the Krebs cycle;
NAD/FAD are hydrogen acceptors in respiration;
if deficient electron transport chain may be impaired so less ATP produced; **max 4**

TOTAL 7

QUESTIONSHEET 12

(a) glycolysis; **1**

(b) X ATP;
Y ADP; **2**

(c) (i) facilitated diffusion/active transport; **1**

(ii) cytoplasm; **1**

(d) (i) to make glucose reactive/phosphorylation gives energy of activation/keeps glucose inside cell/there are no carriers for glucose-6-phosphate in the cell membrane/keeps concentration of free glucose inside cell low so maintains concentration gradient; **1**

(ii) they lack mitochondria;
therefore rely on glycolysis to provide energy; **2**

TOTAL 8

QUESTIONSHEET 13

(a) (i) liver; **1**

(ii) deamination/transdeamination; **1**

(iii) limited solubility of ammonia in water means too much water would be lost when excreting the amounts of ammonia produced;
mammals being land animals cannot risk losing too much water;
[allow 1 mark only if say 'would incur too much water loss] **2**

(b) (i) liver; **1**

(ii) (by-product of) respiration; **1**

(iii) because ammonia and carbon dioxide are attached to it to assemble urea;
it is reformed when the urea is split off it: **2**

(iv) hydrolysis; **1**

(v) urea is more soluble in water than ammonia;
thus involves less water loss in urine which is advantageous to a land animal/no need to carry large volumes of urine around; **2**

TOTAL 11

QUESTIONSHEET 14

(a) diffusion is the movement of molecules down a concentration gradient;
energy is released as molecules diffuse;
active transport is the movement against a concentration gradient;
involves the expenditure of energy/ATP;
involves the use of carriers;
max 4

(b) (i) oxidative phosphorylation; **1**

(ii) proton pumps;
because they move hydrogen ions which are protons; **2**

(iii) enables protons/hydrogen ions to diffuse back across the membrane;
ref to proton motive force/surplus of positive ions on inside of membrane;
movement of protons back releases energy;
which is harnessed by enzyme to convert ADP + P to ATP; **max 3**

TOTAL 10

QUESTIONSHEET 15

(a) the volume of carbon dioxide evolved;
divided by the volume of oxygen absorbed;
(or allow, moles/molecules of carbon dioxide evolved;
divided by moles/molecules of oxygen used;) **2**

(b) (i) RQ = $\frac{114}{160}$; = 0.7125 (allow 0.71) ; **2**

(ii) RQ when respiring only carbohydrate would be 1.0;
because volume CO_2 released ($6CO_2$) equals volume of O_2 used ($6O_2$);
RQ when respiring only fat is 0.7;
humans respire both carbohydrate and fat at the same time; **max 3**

(c) (i) there would be no movement of the fluid in the manometer; **1**

fluid in the manometer would move towards the peas; **1**

(ii) use water bath/incubator to keep temperature constant thus avoiding gas volume changes;
stated suitable temperature (15 – 25°C);
have tap open and allow time (at least 10 minutes) to equilibrate;
close tap and allow to work for suitable time (at least 30 minutes); **max 3**

(iii) glycolysis, Krebs cycle, respiratory chain/electron transport chain; **1**

TOTAL 13

QUESTIONSHEET 16

(a) (i) glucose must be activated/given energy before it can be metabolised/made more reactive;
phosphorylating with the energy rich bond of ATP gives glucose the extra energy needed; **2**

(ii) changing to a different structural molecular shape whilst retaining the same empirical/molecular formula; **1**

(iii) enolase is substrate specific for fructose/cannot accept glucose as a substrate; **1**

(iv) to produce reduced NAD/NADH/$NADH_2$;
which can be used/reoxidised in the respiratory chain/electron transport chain;
so that ATP is synthesized; **max 2**

(b) (i) yeast respires/produces carbon dioxide and water, using the normal aerobic pathway when oxygen is available;
when oxygen is missing $NADH_2$ has to be reoxidised without the use of the electron transport chain;
this is done by decarboxylating pyruvic acid/removing CO_2 from pyruvic acid, to form ethanal;
this is hydrogenated/reduced to ethanol using $NADH_2$ which is reoxidised to NAD; **4**

(ii) Lactobacilli are prokaryotic and so have no mitochondria/respiratory chain is not highly organised;
thus $NADH_2$ is reoxidised by hydrogenating/reducing pyruvic acid to lactic acid; **2**

(iii) yoghurt manufacture; **1**

(b) Lactobacilli/bacteria in the mouth/buccal cavity produce lactic acid;
this can cause decay/erode enamel of teeth;
if enolase is inhibited then the bacteria cannot produce the lactic acid;
(credit any reference to fluoride being incorporated into the enamel, thus hardening it) **max 2**

TOTAL 15

QUESTIONSHEET 17

(a) (i) it is the volume of carbon dioxide /number of carbon dioxide molecules or moles liberated;
divided by the volume of oxygen/number of oxygen molecules or moles used; **2**

(ii) because they do not respire only carbohydrate or only fat but a mixture of them;
protein is not usually respired in large amounts except in starvation; **2**

(iii) when they are using the carbon dioxide for something else and so not releasing it;
for example, in photosynthesising plants; **2**

(b) (i) barley seeds are respiring mainly starch and so have a RQ approaching 1.0;
castor oil seeds store oil and so are respiring fat (oil) and so have a RQ approaching 0.7;
barley seeds contain little lipid whereas castor oil seeds contain little starch; **max 2**

(ii) photosynthetic leaves/cotyledons/coleoptiles will have formed;
thus starch synthesis occurs and both sets of seeds can now respire carbohydrate;
initial starch content/oil content probably used up; **max 2**

TOTAL 10

QUESTIONSHEET 18

(a) (i) amino acids cannot be stored since their amine groups are toxic;
deamination removes the amine groups of surplus amino acids for excretion; **2**

(ii) in the liver/hepatic cells; **1**

(b) (i) it is respiratory since NADH is produced by dehydrogenation (and this can be used to generate ATP);
it also generates pyruvic acid which can be used in the Krebs cycle (to generate more ATP);
it is excretory since it removes toxic amine groups as ammonia (for excretion); **3**

(ii) pyruvic acid forms acetyl coenzyme A in the link reaction;
which is further metabolised in the Krebs cycle; **2**

NADH is reoxidised to NAD in the respiratory chain/electron transport chain;
resulting in ATP synthesis; **2**

ammonia enters the ornithine cycle to be assembled into urea;
which is transported by the blood to the kidneys for excretion; **2**

TOTAL 12

QUESTIONSHEET 19

phosphorylation/adding phosphate; ATP/adenosine triphosphate; fructose diphosphate; triose phosphate; NADH; glycolysis; cytoplasm; mitochondrion; inner; respiratory chain/electron transport chain; three; protons/hydrogen ions; oxygen; cytochrome; link; Krebs cycle;

TOTAL 16

QUESTIONSHEET 20

(a) false;
body proteins are continually recycled/broken down and replaced;
amino acids formed are toxic;
so if not immediately used for protein reassembly must be deaminated;
surplus dietary amino acids are also deaminated;
deamination generates NADH (for ATP synthesis) and so is a respiratory process; **max 5**

(a) true;
camel will be short of water (in desert);
water is a byproduct of respiration;
respiration of 1 gramme of fat yields more water than respiration of 1 gramme of carbohydrate;
almost twice as much water yielded from fat; **max 4**

(b) false;
if oxygen is available yeast respires by the aerobic pathway;
when oxygen is not available NADH must be reoxidised in an alternative way;
by converting pyruvic acid to ethanol; **max 3**

TOTAL 12