

Q1.

- 2 (a) provides energy;
suitable examples;
e.g. muscle contraction, protein synthesis, DNA replication, cell movement, active transport
- 3
- (b) *substrate level phosphorylation* cytoplasm (in glycolysis);
oxidative phosphorylation matrix of mitochondria (in Krebs cycle);
inner membrane of mitochondria/cristae;
- 2 max
- (c) oxidative phosphorylation more than substrate level phosphorylation;
ref. to quantity, e.g. 32/34 vs. 4/6 per glucose;
- 2
- (d) requires proton gradient produced by ETC;
with no oxygen ETC does not occur/no electron flow;
NAD cannot be reformed/NADH cannot be oxidised;
oxygen combines with electron/proton/oxygen final acceptor in ETC;
- 3 max
- Total: 10

Q2.

Question 2

- (a) (i) correctly indicated on inner membrane ;
(ii) correctly indicated in matrix ;

2

- (b) folded inner membrane / cristae ;
increases surface area available ;

intermembrane space ;
allows accumulation of H^+ ;

impermeability of inner membrane to H^+ ;
maintains H^+ gradient / H^+ only go through channels ;

stalked particles / ATPase ;
channel for H^+ / ATP synthesis ;

linear arrangement of ETC on inner membrane ;
greater efficiency ;

4 max

- (c) (no) oxygen to combine with e^- / H^+ / H / $2H$ / proton ;
at the end of the ETC ;
no H^+ gradient produced ;
no ATP synthesized / oxidative phosphorylation does not occur ;
no NAD regenerated / NADH not oxidized ;
stops Krebs cycle ;

3 max

Total: 9

Q3.

Question	Marks
<p>1 (a) a nucleotide ; with <u>three</u> phosphate groups ; an organic / nitrogenous base / adenine ; a pentose sugar / ribose ; ref. ester linkages / covalent bonds ;</p>	3 max
<p>(b) synthesized from ADP and P_i ; soluble molecule ; diffuses rapidly / transported easily ; on hydrolysis / removal of (third) phosphate ; energy released / 30.5 kJ (mol⁻¹) ; ref.(idea) intermediary (between energy yielding and energy requiring reactions) ;</p>	3 max
<p>(c) oxidative phosphorylation ; NADH₂ to, cristae / inner membrane ; oxidised to NAD ; ref. transfer of electrons to electron carriers / ETC ; H⁺ pumped into intermembrane space ; ref. to H⁺ gradient ; H⁺ (diffuses) through ATP synthase / stalked particle ; results in ADP and P_i to ATP ; ref. chemiosmosis ; ref. substrate level phosphorylation ;</p>	4 max

Q4.

Question	Expected Answers	Marks
1 (a)	cytoplasm ;	[1]
(b)	hexose bisphosphate / phosphorylated 6C sugar / fructose bisphosphate ;	[1]
(c)	hexose energy rich ; does not react easily / AW ; phosphorylation activates hexose ; maintains concentration gradient of glucose inside and outside cell ;	[2 max]
(d)	does not enter Krebs cycle ; decarboxylated / CO ₂ released ; forms ethanal ; reduced / ref: reduced NAD ; to ethanol ; reduced NAD does not enter ETC ; ref: alcohol dehydrogenase ; irreversible ;	[4 max]
		[Total: 8]

Q5.

2

process	major products
glycolysis	ATP ; pyruvate ; reduced NAD ;
Krebs cycle	ATP ; reduced NAD / reduced FAD ; CO ₂ ;
oxidative phosphorylation	ATP ; water ; NAD / FAD ;

[8 max]

R NADP throughout

[Total: 8]

Q6.

- 1 (a) (i) 18 ; [1]
- (ii) 0.72 ;
- allow ecf from (i)* [1]
- (b) 1 RQ value falls steeply, initially / 40–80 min ;
- 2 then, very little change / AW ;
- 3 sugar / carbohydrate, metabolised at start ; **A** named carbohydrate
- 4 then fat metabolised ;
- 5 (due to) fasting / carbohydrate running out ; [4 max]
- (c) 1 increase in rate of respiration ;
- 2 kinetic energy increases / more enzyme-substrate complexes / enzyme activity increases ;
- 3 effects of too high a rise in temperature ; e.g. denaturation of enzymes
- 4 AVP ; e.g. $Q_{10} = 2$ [2 max]
- [Total: 8]

Q7.

- 7 (a) (i) glycolysis ; [1]
(ii) cytoplasm/cytosol ; [1]
(iii) 4 ; $A_4 - 2 = 2$ [1]
- (b) (i) inner membrane/cristae/stalked particles ; [1]
(ii) 1 reduced, NAD/FAD ;
2 dehydrogenase enzymes ;
3 release hydrogen ; $AH \rightarrow R H_2/H^+$
4 hydrogen splits into proton and electron ;
5 electrons flow down, ETC/AW ;
6 energy released ;
7 protons pumped (across inner membrane/from matrix) ;
8 into intermembrane space ;
9 proton gradient ;
10 protons pass through, ATP synthase/stalked particle ;
11 oxygen final, hydrogen/proton, acceptor ; [5 max]
- (c) (i) nuclei and ribosomes ; [1]
(ii) 1 glycolysis, does not occur in mitochondrion/only occurs in cytosol or cytoplasm ;
2 pyruvate produced in glycolysis ;
3 pyruvate can enter mitochondrion/glucose cannot enter mitochondrion ;
4 carbon dioxide produced/decarboxylation, in, Krebs/link reaction ; [3 max]
(iii) 1 cyanide, inhibits cytochrome oxidase is a non-competitive inhibitor ;
2 reduced NAD not oxidised/AW ;
3 Krebs cycle stops ;
4 alternative H acceptor needed/pyruvate is H acceptor/pyruvate is reduced ; RH^+
5 lactate produced in cytoplasm ;
6 by anaerobic respiration ; [3 max]

[Total: 16]

Q8.

7 (a) (i) removal of, carbon dioxide/carboxyl group ; [2]
removal of hydrogen ;

(ii) P and Q ; [1]

(b) (i) 3 ; [1]

- (ii)
- 1 inner mitochondrial membrane/cristae ;
 - 2 dehydrogenase enzymes ;
 - 3 release hydrogen ;
 - 4 hydrogen splits into protons and electrons ;
 - 5 electrons flow down, ETC/Electron Transfer Chain/AW ;
 - 6 energy released ;
 - 7 protons pumped across (inner membrane) ;
 - 8 into intermembrane space ;
 - 9 proton gradient ;
 - 10 protons pass through, ATP synthase/stalked particles ;
 - 11 ATP formed ; *linked to 10*
 - 12 oxygen (final), hydrogen/proton and electron, acceptor ;

max 4 [5 max]

(c) 1 pyruvate converted to ethanal ;

2 ethanal reduced ;

3 by reduced NAD ;

4 NAD, oxidised/regenerated ;

5 allows glycolysis to continue ;

6 ethanal dehydrogenase ;

7 ethanol formed ;

8 prevents H⁺ from lowering pH ;

[4 max]

- (d) 1 no, decarboxylation/carbon dioxide removed ; **A** ora
 2 single step ;
 3 lactate dehydrogenase ;
 4 reversible ;

[3 max]

[Total: 16]

Q9.

- 7 (a) active transport ;
ribose ;
 water ;
 hydrolysis ; **A** dephosphorylation
 heat ;

[5]

- (b) (i) (converted to) glycogen / lipid ;
 (used in) glycolysis / respiration ;

[1 max]

(ii) *anaerobic*

1. less ATP / only 2 ATP ;
2. per mol glucose ;
3. lactate still contains energy / only glycolysis involved / stages other than glycolysis not involved ;
4. not sustainable / cannot go on indefinitely / AW ;

[2 max]

(iii)

process	precise location
glycolysis	cytoplasm / cytosol ;
link reaction	mitochondrial matrix ;
Krebs cycle	mitochondrial matrix ;
oxidative phosphorylation	inner mitochondrial membrane / cristae ;

[4]

- (iv) 1. cannot pass through phospholipid bilayer ;
 2. too big to fit through (glucose's) protein channel ;
 3. no specific transport protein ;
 4. AVP ; e.g. used up as soon as it is made

[2 max]

- (v) oxygen debt ;

[1]

[Total:15]

Q10.

- 6 (a) (i) decarboxylation ; [1]
(ii) dehydrogenation / oxidation ; [1]
(iii) substrate level phosphorylation ; [1]
- (b) K – reduced NAD ; A NADH etc. [2]
L – oxaloacetate ;
- (c) 1. hydrogens split into protons and electrons ;
2. electrons pass along ETC ;
3. energy released used to pump protons ;
4. (from matrix) to intermembrane space ;
5. inner membrane impermeable to protons ;
6. proton gradient forms ;
7. protons move down gradient ;
8. through ATP, synthase / ATP synthetase ; R ATPase
9. enzyme rotates ;
10. ATP produced ; [5 max]

[Total: 10]

Q11.

- 4 (a) (i) 1. ATP is made, in the electron transport chain/by oxidative phosphorylation;
2. oxygen is the final electron acceptor;
3. in the, inner membrane of the mitochondrion/cristae;
4. transfer of electron (between electron carriers) provides energy;
5. energy used to pump hydrogen ions (into intermembrane space);
6. creates proton gradient;
7. diffusion of hydrogen ions down their electrochemical gradient causes ATP to be synthesised;
8. ref. chemiosmosis/ATP synthase/stalked particles;
9. idea that if less oxygen (consumed/available) then fewer electrons transferred along the chain; [max 4]
- (ii) 1. at high temperatures, reactions/enzyme activity/metabolism, faster;
2. because, molecules/enzymes/substrates, have more kinetic energy;
3. more frequent collisions;
4. therefore, respiration/Krebs cycle/electron transport chain/production of reduced NAD, take place at a faster rate;
5. idea of increase in rate of anabolic reactions (requiring more ATP); [max 3]

- (b) (i) 1. oxygen consumed = oxygen inhaled – oxygen exhaled;
 2. measure oxygen consumption at rest (x) **and** after exercise stops (y);
 3. extra oxygen consumed/oxygen debt = y – x;
 4. measure mass of lizard; [max 2]
- (ii) 1. less (oxygen debt)(for *Varanus*); **ora**
 2. difference is greater at higher temperatures;
 3. any two comparative figures at one temperature including units; [3]
A 102.0 cm³ O₂ kg⁻¹ at 30°C and 40°C

- (iii) 1. *Varanus* uses, less anaerobic/more aerobic, respiration (when running);
 2. more ATP produced per glucose molecule;
 3. able to run for long time;
 4. good chance of catching prey; [max 3]

- (iv) *assume Varanus throughout*
 1. larger surface area, in lungs/for gas exchange;
 2. more oxygen absorbed into blood (per unit time)/faster rate of gas exchange;
 3. more oxygen supplied to muscles (so oxygen debt lower); [max 2]

[Total: 17]

Q12.

- 4 (a) (i) inner membrane / crista(e); [1]
- (ii) 1. (electron comes from) hydrogen (atom); $\text{R H}^+ / \text{H}_2$
 2. (from) reduced NAD / reduced FAD;
 3. (from) dehydrogenation / oxidation, reactions;
 4. (from substances in) Krebs cycle / link reaction / glycolysis;
 5. in, matrix of mitochondrion / cytoplasm; [max 3]
- (iii) 1. final electron acceptor / accepts electron from last carrier;
 2. so carrier can be reduced again;
 3. so electrons can keep flowing (along ETC) / so ETC can continue to work;
 4. (oxygen) combines with H^+ to form water; [2 max]
- (b) (i) 1. (when pump stops working), resting potential not maintained
or
 pump usually maintains the resting potential;
 2. (during resting potential) membrane polarised
or
 positive charge outside (neurone) / negative charge inside (neurone) / -70mV inside neurone relative to outside / potential difference across membrane;
 3. (when pump stops working), ions (only) move by diffusion;
 4. Na^+ **into** the neurone;
 5. outward diffusion of K^+ is limited / K^+ stay in neurone;
 6. ref. non voltage-gated channels;
 7. (eventually) inside of the neurone, becomes less negative / contains (relatively) more positive ions
or
 there is a reduced potential difference across the membrane; [max 4]
- (ii) 1. voltage gated (calcium) channels open;
 2. (calcium ions move in) by diffusion / move down their concentration gradient; [2]

- (c) (i) 1. Na^+ / K^+ , cannot move through membrane;
2. so potential across membrane maintained even when pump stops / so membrane depolarisation does not happen;
3. calcium ions cannot enter cell;
4. so, (destructive) enzymes not activated; [max 2]
- (ii) 1. gene (for protein channels), expressed less / switched off;
2. transcription, reduced / stopped;
3. AVP; e.g. reduced aerobic respiration / less ATP, for transcription [max 2]

[Total: 16]

Q13.

Question 2
(a)

	name of structure	stage of respiration
A	matrix	Krebs cycle ;
B	cristae / inner membrane A intermembrane space	oxidative phosphorylation/ETC ; A build up of protons

Penalise once if rows A and B are correct but swapped
if both structure names are correct (but stages incorrect) allow one mark

2

(b)
membranes separate from rest of cytoplasm ;
allows different pH ;
inner membrane attachment of stalked particles / ATPase ;
allows linear / ordered arrangement of carriers/ETC/respiratory chain ;
ref. to large internal surface area/AW ;
matrix contains enzymes;

3 max

(c)
carries / transfers protons/hydrogen(atoms) ;
and electrons ;
in/to ETC /FAD/respiratory chain;
ref. to dehydrogenation/oxidising ;
energy used to form ATP;
ref. to coenzyme ;
ref. alternative pathways (named);

3 max

(d)
light involved ;
occurs in chloroplasts/chlorophyll ;
on thylakoid membranes ;
ref. to cyclic and non-cyclic ;
photolysis of water/produces oxygen;

If oxidative phosphorylation stated
light not involved;
oxygen final hydrogen acceptor/oxygen not evolved;

3max

Total: 11

Q14.

		Total : 5
Question 2		
(a)	cytoplasm ; matrix in mitochondria ;	2
(b)	coenzyme ; carries electrons / protons / hydrogen ions / hydrogen / H / 2H / H ⁺ ; to electron transfer chain / AW ; from glycolysis / link reaction / Krebs cycle ; role of NAD in conversion / oxidation of triose phosphate to pyruvate in glycolysis ; role of NAD in anaerobic respiration ;	R H ₂ 3 max
(c)	in absence of oxygen electron transfer chain does not work ; oxygen final acceptor at end of electron transfer chain ; reduced NAD cannot be oxidised ;	3
(d)	aerobic respiration produces more ATP / (ora); to produce the same amount of ATP more glucose broken down in glycolysis ; glycolysis is the only part of respiration used / no ETC or oxidative phosphorylation ;	2 max
		Total : 10

Q15.

3	(a) 1 no increase below 40 au; 2 (most) rapid production above 60 au; 3 correct reference to Figs.;	2 max
	(b) 1 glucose to pyruvate/glycolysis; 2 pyruvate to lactate; 3 reference lactate dehydrogenase; 4 in absence/shortage of oxygen to <u>muscles</u> ; 5 pyruvate acts as a hydrogen acceptor; 6 reduced NAD to NAD/NAD regenerated;	3 max
	(c) 1 lactate must be oxidised; 2 extra oxygen required; 3 this is the oxygen debt; <i>linked to point 2</i>	3
	(d) more anaerobic respiration/insufficient oxygen supply;	1
		Total 9

Q16.

Question 1

- (a) matrix of mitochondria ; [1]
- (b)(i) 3 sites labeled ;; *deduct one mark for each additional or missing label*
- (ii) 5 sites labeled ;; [3 max]
- (c) reduced NAD ;
ref. to ETC ;
oxidized / give up hydrogen ; [3]
- (d) ref. to substrate level phosphorylation;
no proton gradient involved ;
no ATP synthase ;
no ETC ; [1 max]
- Total [8]**

Q17.

Question 3

- (a) $RQ = \frac{\text{volume of carbon dioxide given off}}{\text{volume of oxygen taken up}}$; [1]
- (b)(i) 18 H₂O ;
18CO₂ ; [2]
- (ii) 18/26 ;
= 0.7 ; 2 marks for correct answer [2]
- (iii) fatty acid A lipids / triglycerides / fat / oil ; [1]
- (c) less C-C bonds ;
less C-H bonds ;
more oxygen ; A O R O₂ [2 max]
- Total [8]**

Q18.

Question	Expected Answers	Marks
1 (a)	(<i>carbohydrates</i>) 1 less reduced / less hydrogen / less C-H bonds ; R H₂ 2 for, aerobic respiration / ETC / NAD / ATP ; 3 less energy ; 4 per, unit mass / mole ; <i>accept figs for 3 and 4</i> 5 carbohydrate has lower energy density ; <i>accept as alternative to 3 & 4 for 2 marks</i>	3 max
(b)	carbohydrate = 1.0 ; lipid = 0.6 – 0.8 ;	2
(c)	RQ remains stable between 3°C and 10°C / AW ; rise between 10°C and, 20°C / 25°C ; 0.74 to, 0.76 / 0.8 ; <i>accept difference for figs marks</i> sharp rise, between 25°C and 27°C / after 25°C ; 0.8 to 0.91 / peaks at 0.91 ; 3 max	4 max
(d)	anaerobic respiration / conversion of carbohydrate to fats as animal hibernates;	1
[Total: 10]		

Q19.

7 (a)	1 provides, H ⁺ / protons / protons and electrons ; A hydrogen R H₂ R produce H⁺ 2 forms, reduced NAD / reduced FAD ; A NAD / FAD, accepts H⁺ 3 passed to ETC / cytochromes ; 4 oxidative phosphorylation ; 5 cytochrome oxidase ; 6 forms water (with oxygen) ;	[3 max]
(b) (i)	(initial) steep rise up to 40 (μmol) AI ; 2 paired figs ; ref. plateau above 40 (μmol) AI ;	[2 max]
(ii)	(initially) AI is, activator / cofactor / coenzyme ; detail of shape change of enzyme ; enzyme / substrate, limiting, after 40 (μmol) AI / high conc AI ; A end product <i>inhibition after 40 (μmol) AI</i> [2 max]	[2 max]
[Total: 7]		

Q20.

- 6 (a) (i) phosphorylation ; [1]
(ii) lysis ; [1]

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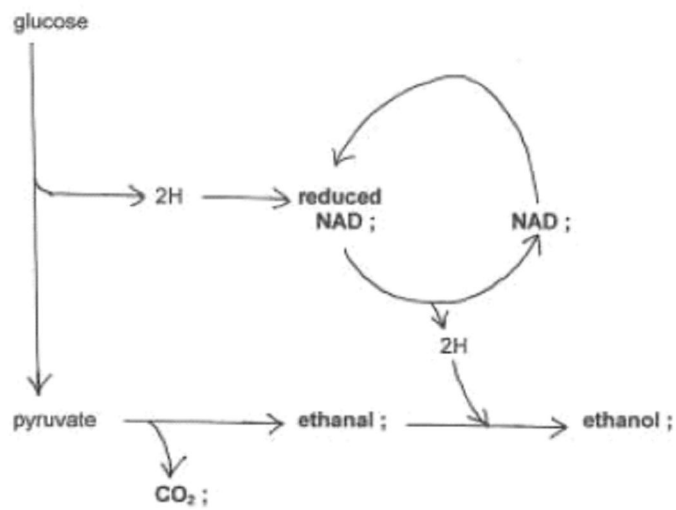
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- (iii) dehydrogenation / oxidation ; *ignore reduction of NAD* [1]
- (b) provides activation energy / AW ;
for it to split / AW ; [2]
- (c) 1. decarboxylated / carbon dioxide given off ;
2. ethanal produced ;
3. ethanal reduced ;
4. by reduced NAD ;
5. to ethanol ;
6. dehydrogenase ; [4 max]

[Total: 9]

Q22.

6 (a)



[5]

(b) *in mammals*

1. lactate produced / no ethanol produced ;
2. no, decarboxylation / carbon dioxide released ;
3. single step ;
4. lactate dehydrogenase ;
5. reversible ;

[3 max]

(c) *in anaerobic respiration*

1. only glycolysis occurs / Krebs cycle stops / link reaction stops ;
2. glucose, not fully broken down / still contains energy ;
3. pyruvate does not enter mitochondrion ;
4. (no oxygen) so no final electron acceptor (in ETC) ;
5. ETC stops ;
6. no oxidative phosphorylation ;

[3 max]

[Total: 11]

Q23.

- 8 (a) X = crista(e) / inner membrane ; [2]
 Y = matrix ;
- (b) (i) raise chemical PE of glucose / provide activation energy / AW ; [1]
 (ii) removes hydrogen / hydrogen carrier / coenzyme ; [1]
 (iii) 4 ; A net 2 [1]
 (iv) dehydrogenation ; A oxidation
 decarboxylation ;
 accept 'oxidative decarboxylation' for two marks [2]
 (v) matrix ; [1]
 (vi) 1. accepted by NAD ;
 2. passed to ETC ;
 3. for oxidative phosphorylation ;
 4. ref. proton pump / chemiosmosis ; [2 max]
- (c) 1. found in all organisms ;
 2. loss of phosphate / hydrolysis, leads to, energy release /
 release of 30.5 kJ (per mole) ;
 3. $ADP + P_i \rightleftharpoons ATP$ / reversible reaction ;
 4. small packets of energy ;
 5. small / water soluble, so can move around cell ;
 6. (used by cells as) immediate energy donor ;
 7. link between energy yielding and energy requiring reactions / AW ;
 8. high turnover ;
 9. example of use ; e.g. active transport / muscle contraction / Calvin cycle /
 protein synthesis [5 max]

[Total:15]

Q24.

- 8 (a) (i) cytoplasm / cytosol ; [1]
- (ii) 1 NAD regenerated ;
2 so glycolysis can continue ;
3 to produce ATP ; [2 max]
- (iii) lactate dehydrogenase ; [1]
- (iv) *reaction* - condensation / polymerisation ;
bond - glycosidic ; [2]
- (b) *in yeast*
- 1 decarboxylation / CO₂ removed ;
2 ethanal (as intermediate step) ;
3 ethanol produced ;
4 two steps (from pyruvate) ;
5 ethanol dehydrogenase ;
6 not a reversible reaction / ethanol cannot be converted back to pyruvate ;
7 *idea of process less energy efficient ;*
allow ora for mp1, mp4, mp5, mp6 and mp7 [4 max]
- (c) (i) carbon dioxide produced divided by oxygen consumed ;
volume / number of moles (of both gases) ; [2]
- (ii) carbohydrate = 1.0 ;
lipid = 0.7 ; [2]
- (iii) increase / go above one / infinity ; [1]
- [Total: 15]

Q25.

- 3 (a) adenine / nitrogen(ous) base / purine ; **R** adenosine
ribose / pentose ; [2]
- (b) 1. (cell uses) ATP as source of energy ;
2. ATP broken down ;
3. (so) cell must regenerate ATP ;
4. from ADP and Pi ;
5. ref. ADP / AMP, must be synthesised in the cell ; [max 2]

- (c) (i) 1. palmitic acid has **more**, hydrogens / C-H bonds ;
 2. per mole ;
 3. hydrogens needed for, ATP production / chemiosmosis / oxidative phosphorylation ;
 [max 2]
- (ii) *alanine* – starvation / lack of fat or carbohydrate ;
lactate – after anaerobic respiration ; [2]
- [Total: 8]

Q26.

- 3 (a) 1. oxidative phosphorylation ;
 2. oxygen is **final** electron acceptor ;
 3. reduced to water / accepts hydrogen ion to form water ; **A** equation
 4. so electron transport chain can continue ; ora
 5. increases ATP production ; ora
 6. in absence of oxygen only glycolysis continues ; [max 3]

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- (b) (i) 1. lipid releases most energy ;
 2. because it has more, hydrogens / C-H bonds ;
 3. per unit mass ;
 4. hydrogens needed for, ATP production / chemiosmosis ; [max 3]
- (ii) many more hydrogens available to, reduce / convert, oxygen to water ; [1]
- [Total: 7]

Q27.

- 2 (a) (i) substrate level ;
 protein synthesis / DNA replication / glycogenesis / polymerisation ;
 active transport / movement of chromosomes / sliding filaments / movement of vesicles /
 AW ; [3]
- (ii) water ; [1]
- (iii) ATP, synthase / synthetase ; R ATPase [1]

Q28.

- 8 (a) (DNA for) transcription/ codes for mRNA ;
 (ribosomes for) translation ;
 synthesis of, respiratory enzymes/named enzyme/ inner membrane proteins ; [max 3]

(b)

correct order	letter of stage
1	V
2	S
3	U
4	W
5	R
6	Q
7	X
8	T

S U W all above **R** ;
S U W in correct order ;

Q X T all below **R** ;
Q X T in correct order ;

[4]

(c) hydrolysis / dephosphorylation / exothermic / exergonic ;

[1]

(d) anaerobic respiration ;

substrate level phosphorylation (in glycolysis);

at triose phosphate \longrightarrow pyruvate step ;

(net) gain of 2ATP (per glucose) ; **A** 2 used and 4 produced

pyruvate, reduced / gains hydrogens (from reduced NAD) ;

forming lactate ;

NAD regenerated / NADH₂ re-oxidised ;

this allows glycolysis to continue ;

I ethanol pathway

[max 5]

[Total:13]

Q29.

- 8 (a) (i) receptors/hypothalamus, detect change in blood temperature ;
 brain ;
 (receptor/brain) sends impulses to effector ;
 effector carries out response /example of response ;
 blood temperature returns to normal ;
 negative feedback ; [max 4]
- (ii) larger SA:V ratio ;
 lose (relatively) more heat ;
 ref. more mitochondria to release heat energy ;
 cannot carry out behavioural actions to get warm ;
 infants cannot shiver ; [max 2]
- (b) (i) **A** – ATP synthase /ATP synthetase /stalked particles ; **R** ATPase
B – inner membrane/ crista ; **I** phospholipid bilayer [2]
- (ii) arrow going down from intermembrane space to matrix ; [1]
- (iii) **1 and 3** ; [1]
- (iv) water ; [1]
- (v) fatty acids ; **A** lipid /fat /triglycerides [1]
- [Total:12]

Q30.

- 5 (a) contains ribose (not deoxyribose) ;
 has three phosphate groups (not one) ; [2]

(b) (i) *anaerobic – accept ora for aerobic*

- 1 *idea that glucose not completely, broken down / oxidised*
or
only glycolysis occurs ;
- 2 *pyruvate / lactate / ethanol, still contains energy ;*
- 3 *ETC stops ;*
- 4 *(because) no oxygen to act as (final) electron acceptor ;*
- 5 *(so) no, Krebs cycle / link reaction / oxidative phosphorylation / chemiosmosis ;*

[max 3]

- (ii)
- 1 *lipid contains (relatively) more, hydrogen atoms / C-H ;*
 - 2 *detail ; e.g. molecular formula of glucose and a lipid given*
 - 3 *more reduced, NAD / FAD, produced ;*
 - 4 *more electrons passed along ETC ;*
 - 5 *more hydrogen ions pumped across inner mitochondrial membrane / more hydrogen ions pumped into intermembrane space / steeper proton gradient ;*

[max 3]

[Total: 8]

Q31.

- 4 (a) *ignore ref. to energy currency*
- 1 *idea of synthesis of complex substances or synthesis of named large molecule/anabolic reactions;*
 - 2 transport of substances against concentration gradient/active transport ;
 - 3 movement qualified ; e.g. muscle contraction/cilia movement/locomotion
 - 4 AVP ; e.g bioluminescence, electrical discharge, temperature regulation [max 2]
- (b) (i) *both answers required for one mark*
- A adenine R adenosine
- B ribose/pentose ; [1]
- (ii) 1 small ;
- 2 water soluble ;
 - 3 easily transported around the cell ;
 - 4 easily hydrolysed (to release energy) ;
 - 5 (so) relatively large quantity of energy released / 30.5 kJ mol⁻¹ ;
 - 6 *idea of, rapid turnover / small cellular ATP content is sufficient for cell's requirements ;* [max 3]
- (c) (i) 1 less/decreased (aerobic respiration) ;
- 2 oxygen, is the final electron acceptor / needed for ETC ;
 - 3 oxidative phosphorylation decreased / chemiosmosis decreased ;
 - 4 regeneration of NAD / Kreb's cycle / link reaction, decreased ;
 - 5 ATP synthesis decreases / ATP synthetase activity decreased ; [max 2]
- (ii) more ATP produced (for population growth) ; [1]
- (d) (i) 1 HB8 always does better than mutant HB8 ;
- 2 HB8 and mutant HB8 both do better in aerobic than in anaerobic conditions ;
 - 3 data quote to support ;
- for mp1*
 $[950 \times 10^6 \text{ per cm}^3 \text{ v } 900 \times 10^6 \text{ per cm}^3]$ **and** $[490 \times 10^6 \text{ per cm}^3 \text{ v } 410 \times 10^6 \text{ per cm}^3]$ **or** manipulated figures
- for mp2*
 $[950 \times 10^6 \text{ per cm}^3 \text{ v } 490 \times 10^6 \text{ per cm}^3]$ **and** $[900 \times 10^6 \text{ per cm}^3 \text{ v } 410 \times 10^6 \text{ per cm}^3]$ **or** manipulated figures [max 2]

- (ii) 1 both grow better in aerobic compared to anaerobic ;
 2 *ref. to significant difference found in mutant HB8 (aerobic compared to anaerobic) ;*
 3 data quote to support ;

for mp1

[880×10^6 per cm^3 v 460×10^6 per cm^3] **and** [840×10^6 per cm^3 v 50×10^6 per cm^3] **or** manipulated figures

for mp2

[840×10^6 per cm^3 v 50×10^6 per cm^3] **or** [460×10^6 per cm^3 v 50×10^6 per cm^3] **or** manipulated figures

[max 2]

- (iii) *idea that HB8 is a better competitor than mutant HB8 ; ora*

in mutant HB8 activity of, enzyme/nitrate reductase, is reduced ;

[max 1]

[Total: 14]

Section B

1.

- 9 (a) 1 reduced, NAD / FAD ;
 2 passed to ETC ;
 3 inner membrane / cristae ;
 4 hydrogen released (from reduced, NAD / FAD) ; R H2
 5 split into electrons and protons ;
 6 protons in matrix ;
 7 electrons pass along, carriers / cytochromes ;
 8 *ref. redox reactions ;*
 9 *ref. energy gradient ;*
 10 energy released ; R produced
 11 protons (pumped) into intermembrane space ;
 12 proton gradient ;
 13 protons pass through (protein) channels ;
 14 ATP synthase / stalked particles ;
 15 ATP produced ;
 16 chemiosmosis ;
 17 electron transferred to oxygen ;
 18 addition of proton (to oxygen) to form water / (oxygen) reduced to water ;

[9 max]

if candidate mistakenly writes about photosynthesis only allow marking points 7, 8, 9, 10 and 15 to 5 max

- (b) *in cytoplasm*
19 NAD, becomes reduced / accepts H ;
20 during glycolysis ;

- in plants*
21 pyruvate converted to ethanal ;
22 ethanal reduced ;
23 by reduced NAD ;
24 ethanol formed ;

- in animals*
25 pyruvate converted to lactate ;
26 by reduced NAD ;
27 in, liver / muscles ;
28 allows glycolysis to continue ;

[6 max]

allow either 23 or 26

[Total: 15]

2.

- 9 (a) 1. reduced, NAD / FAD ;
2. passed to ETC ;
3. inner membrane / cristae ;
4. hydrogen released (from reduced, NAD / FAD) ; R H_2
5. split into electrons and protons ;
6. electrons pass along, carriers / cytochromes ;
7. ref. energy gradient ;
8. energy released pumps protons into intermembrane space ;
9. proton gradient ;
10. protons pass through (protein) channels ;
11. ATP synthase / stalked particles ;
12. (ATP produced from) ADP and inorganic phosphate ;
13. electron transferred to oxygen ;
14. addition of proton (to oxygen) to form water / (oxygen) reduced to water ;

[8 max]

- (b)
15. organisms need energy, to stay alive / for metabolism / AW ;
 16. ATP as, (universal) energy currency / described ;
 17. light energy for photosynthesis ; **A** light dependent stage
 18. light-dependent stage detail ;
 19. light-independent stage detail ;
 20. chemical energy ;
 21. for anabolic reactions ;
 22. named reaction; e.g. protein synthesis / starch formation
 23. activation of glucose in glycolysis / described ;
 24. active transport ;
 25. detail; e.g. sodium - potassium pump /movement against a concentration gradient
 26. mechanical energy / movement ;
 27. detail ; e.g. muscle contraction / spindle

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28. temperature regulation ;

29. AVP ; e.g. bioluminescence / electrical discharge

[7 max]

[Total: 15]

3.

9 (a) *Active transport or anabolic reactions*

1. ATP provides energy (linked to either) ; *ignore ref. to energy currency alone*

active transport

2. movement against concentration gradient ;
3. carrier / transport, protein (in membrane) ; *ignore pump*
4. binds to (specific) ion ;
5. protein changes shape ;

anabolic reactions

6. synthesis of complex substances from simpler ones ;
7. starch / cellulose / glycogen, from, monosaccharides / named monosaccharides / named sugar ;
8. glycosidic bonds ;
9. lipid / triglyceride, from fatty acids and glycerol ;
10. ester bonds ;
11. polypeptides / proteins, from amino acids ;
12. peptide bonds ;
13. other named polymer from suitable monomer ;
14. appropriate named bond ;

5 max

[7 max]

- (b) *general*
15. reduced NAD produced in glycolysis ; **A** glycolysis described
 16. small amount of ATP produced in glycolysis ;
- in yeast cells*
17. pyruvate converted to ethanal ;
 18. carbon dioxide released / decarboxylation ;
 19. ethanal, reduced / accepts H ;
 20. by reduced NAD ;
 21. ethanol formed ;
- in mammalian cells*
22. pyruvate converted to lactate ;
 23. by reduced NAD ;

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24. in, liver / muscle, cells ;
 25. AVP ;;
 26. e.g. reversible in mammal / irreversible in yeast / single step in mammal / more than 1 in yeast / reoxidised NAD allows glycolysis to continue / named enzyme
- only award either mp19 or mp23* [8 max]

[Total: 15]

4.

6 (a) Describe the main features of the Krebs Cycle. [9]

(b) Explain the role of NAD in aerobic respiration. [6]

- (a)
- 1 matrix;
 - 2 of mitochondrion;
 - 3 acetyl CoA combines with oxaloacetate;
 - 4 to form citrate;
 - 5 4C to 6C;
 - 6 decarboxylation/produce CO₂;
 - 7 dehydrogenation/oxidation;
 - 8 2CO₂ released;
 - 9 reduced NAD produced; *accept reduced coenzyme for one mark - annotate 9/10*
 - 10 reduced FAD produced;
 - 11 ATP produced;
 - 12 series of steps/intermediates;
 - 13 enzyme catalysed reactions;
 - 14 oxaloacetate regenerated;
 - 15 AVP;

9 max

(b) 16 coenzyme;

- 17 for dehydrogenase;
- 18 reduced;
- 19 carries electrons;
- 20 and protons/H⁺/H/hydrogen; R H₂/hydrogen molecules
- 21 from Krebs cycle;
- 22 and from glycolysis;
- 23 to cytochromes/electron transfer chain;
- 24 reoxidised/regenerated;
- 25 ATP produced;
- 26 3/2.5 (molecules of ATP) per reduced NAD;

6 max

Total 15

5.

- 7 (a) Describe the transfer of energy to ATP during photosynthesis. [6]
(b) Describe the process of oxidative phosphorylation. [9]

[Total: 15]

- (a) 1 light absorbed by chlorophyll / AW ;
2 ref. photosystems ;
3 ref. harvesting clusters / accessory pigments ;
4 reaction centre / P680 / P700 ;
5 excitation of electrons / AW ;
6 ETC ;
7 idea of different energy levels ;
8 $\text{ADP} + \text{P}_i \rightarrow \text{ATP}$;
9 cyclic / non-cyclic, photophosphorylation ;
10 chemiosmosis / ATP synthase / description ; 6 max

- (b) 11 reduced NAD / FAD ;
12 passed to ETC ;
13 hydrogens removed ; R H₂
14 split into H⁺ and e⁻ ;
15 e⁻ passed to carriers ;
16 H⁺ stays in mitochondrial matrix ;
17 oxygen final e⁻ carrier ;
18 joins with H⁺ / reduced ; R H₂ / hydrogen
19 forms water ;
20 ref. energy levels of carriers ;
21 energy available to convert ADP and P_i to ATP ;
22 occurs three times (for each reduced NAD) / ref. total yield ;
23 chemiosmosis / ATP synthase / description ; 9 max

[Total: 15]

6.

9	(a)	1	(glucose) phosphorylated by ATP ;	[7 max]
		2	raises energy level / overcomes activation energy ;	
		3	hexose biphosphate ;	
		4	lysis / splitting, of, glucose / hexose ; R sugar splitting	
		5	breaks down to two TP ; A GALP / GADP / G3P / PGAL	
		6	6C → 2 x 3C ;	
		7	dehydrogenation / description ;	
		8	<u>2</u> NAD reduced formed (from each TP to pyruvate formed) ;	
		9	4 ATP produced / net gain of 2 ATP ;	
		10	pyruvate produced ;	
		11	reduced NAD → oxidative phosphorylation / redox ; <i>accept flow diagram</i>	
(b)	12	nucleotide ;	[8 max]	
	13	adenine + ribose / pentose + three phosphates ;		
	14	loss of phosphate leads to energy release / hydrolysis releases 30.5 kJ ;		
	15	ADP + Pi ↔ ATP (reversible reaction) ;		
	16	synthesised during, glycolysis / Krebs cycle / substrate level phosphorylation ;		
	17	synthesised, using electron carriers / oxidative phosphorylation / photophosphorylation ;		
	18	in, mitochondria / chloroplasts ;		
	19	ATP synthase / ATP synthetase ;		
	20	chemiosmosis / description;		
	21	used by cells as <u>immediate</u> energy donor ;		
	22	link between energy yielding and energy requiring reactions / AW ;		
	23	active transport / muscle contraction / Calvin cycle / protein synthesis ;		
				[Total: 15]

7.

9	(a)	1	acetyl CoA combines with oxaloacetate ;	[9 max]
		2	to form citrate ;	
		3	4C to 6C ;	
		4	decarboxylation / CO ₂ released ;	
		5	dehydrogenation / oxidation / release of hydrogen ;	
		6	reduced NAD produced / NAD accepts hydrogen ;	
		7	reduced FAD produced / FAD accepts hydrogen ;	
		8	ATP produced ;	
		9	substrate level phosphorylation ;	
		10	series of, steps / intermediates ; A many named steps off a diagram	
		11	enzyme catalysed reactions ;	
		12	oxaloacetate regenerated ;	
		13	occurs in mitochondrial matrix ;	
			<i>accept diagram</i>	

			<i>accept diagram</i>	
	(b)	14	coenzyme ;	[6 max]
		15	for dehydrogenase ;	
		16	<u>reduced</u> ;	
		17	carries, electrons <u>and</u> protons / hydrogen / NAD	
		18	<u>from</u> Krebs cycle ;	
		19	and glycolysis ;	
		20	<u>to</u> ETC / electron carrier chain / oxidation ;	
		21	reoxidised / regenerated hydrogen removed ;	
22	ATP produced ;			
				[Total: 15]

8.

- 10 (a) 1 ATP as universal energy currency ;
 2 light energy needed for photosynthesis ;
 3 ATP used conversion of GP to TP ;
 4 ATP used to regenerate RuBP ;
 5 (energy needed for) anabolic reactions ;
 6 protein synthesis / starch formation / triglyceride formation ;
 7 activation energy ;
 8 (activate) glucose in glycolysis ;
 9 active transport ;
 10 example ; e.g. sodium / potassium pump
 11 movement / locomotion ;
 12 example ; e.g. muscle contraction / cilia beating
 13 endocytosis / exocytosis / pinocytosis / bulk transport ;
 14 temperature regulation ;

[9 max]

- (b) 15 idea of lipid > protein > carbohydrate / AW ; A lipid has more energy than either protein or carbohydrate
 16 comparative figures ; e.g. 39.4, 17.0 and 15.8 *accept any two*
 17 kJ g^{-1} / per unit mass ;
 18 more hydrogen atoms in molecule, more energy ;
 19 lipid have more, hydrogen atoms / C-H bonds ;
 20 (most) energy comes from oxidation of hydrogen to water ;
 21 using reduced, NAD / FAD ;
 22 in ETC ;
 23 detail of ETC ;
 24 ATP production

[6 max]

[Total: 15]

9.

- 10 (a)
- 1 nucleotide ;
 - 2 adenine + ribose / pentose + three phosphates ;
 - 3 loss of phosphate leads to energy release / hydrolysis releases 30.5 kJ ;
 - 4 $ADP + P_i \rightleftharpoons ATP$ (reversible reaction) ;
 - 5 small packets of energy ;
 - 6 small / water soluble, so can move around cell ;
 - 7 used by cells as immediate energy donor ;
 - 8 link between energy yielding and energy requiring reactions / AW ;
 - 9 high turnover ;
 - 10 two examples of use ; ; e.g. active transport / muscle contraction / Calvin cycle /
 - 11 protein synthesis
- [8 max]

- (b)
- 12 Pyruvate, cannot enter mitochondrion / remains in the cytoplasm ;
 - 13 becomes, hydrogen acceptor / reduced ;
 - 14 by reduced NAD ;
 - 15 from glycolysis ;
 - 16 converted to lactate ;
 - 17 lactate dehydrogenase ;
 - 18 allows glycolysis to continue ;
 - 19 no, decarboxylation / CO_2 removed ;
 - 20 single step ;
 - 21 reversible reaction / converted back to pyruvate ;
 - 22 by oxidation ;
 - 23 ref. oxygen debt ;
 - 24 ethanol produced ;

accept ora for marking points 19–23

[7 max]

[Total: 15]

10.

- 11 (a)**
1. multicellular ;
 2. (cells are) differentiated into tissues ;
 3. autotrophic / photosynthetic ;
 4. eukaryotic (cells);
 5. starch is storage compound ;
 6. (some have) chloroplasts / chlorophyll ;
 7. cell wall ;
 8. made of cellulose ;
 9. plasmodesmata ;
 10. large (central) vacuole ;

[max 7]

- (b)**
1. 0.5–1.0 μm , diameter / width ;
 2. double membrane ;
 3. inner membrane folded / cristae ;
 4. hold, stalked particles / ATP synthase / ATP synthetase ;
 5. site of ETC ;
 6. ref. H^+ and intermembrane space ;
 7. ATP production ;
 8. oxidative phosphorylation / chemiosmosis ;
 9. matrix is site of, link reaction / Krebs cycle ;
 10. enzymes in matrix ;
 11. 70S ribosomes ;
 12. (mitochondrial) DNA ;

[max 8]

[Total: 15]

