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); matrix of mitochondria (in Krebs cycle);
oxidative phosphorylation — 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
1	(a)	a nucleotide ;	
		with three phosphate groups ;	
		an organic / nitrogenous base / adenine ;	
		a pentose sugar / ribose ;	
		ref. ester linkages / covalent bonds ;	3 max
	(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) ;	3 max
	(c)	oxidative phosphorylation ;	
		$NADH_2$ 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 ;	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 ; **A** H **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 ; **R** H^+

5 lactate produced in cytoplasm ;

6 by anaerobic respiration ; [3 max]

[Total: 16]

Q8.

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

(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.
L – oxaloacetate ; [2]

(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 cm^3 O_2 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); **R** H^+ / 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.

Question 2

(a) cytoplasm ;
matrix in mitochondria ; **2**

(b) coenzyme ;
carries electrons / protons / hydrogen ions / hydrogen / H / 2H / H^+ ; **R** H_2
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 ; **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 muscles;

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; *linked to point 2* **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 H_2O ;
18CO_2 ; [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 O_2 [2 max]

Total [8]

Q18.

Question			Expected Answers	Marks
1	(a)		*(carbohydrates)*	
		1	less reduced / less hydrogen / less C-H bonds ; **R** H_2	
		2	for, aerobic respiration / ETC / NAD / ATP ;	
		3	less energy ;	
		4	per, unit mass / mole ; *accept figs for 3 and 4*	
		5	carbohydrate has lower energy density ;; *accept as alternative to 3 & 4 for 2 marks*	**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 ; *accept difference for figs marks*	
			sharp rise, between 25°C and 27°C / after 25°C ;	
			0.8 to 0.91 / peaks at 0.91 ; *3 max*	
			at low temperatures hamster uses lipids ;	
			reason ; e.g. more heat generated from lipid respiration	
			at higher temperatures more carbohydrates are used ;	**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*** H_2 ***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) Al ;	
			2 paired figs ;	
			ref. plateau above 40 (µmol) Al ;	[2 max]
		(ii)	(initially) Al is, activator / cofactor / coenzyme ;	
			detail of shape change of enzyme ;	
			enzyme / substrate, limiting, after 40 (µmol) Al / high conc Al ; ***A*** *end product inhibition after 40 (µmol) Al*	[2 max]
				[Total: 7]

Q20.

6 (a) (i) adenine ;

(ii) ribose ; **R** pentose [2]

(b) 1 energy is released when it is hydrolysed ; **A** equation **A** joules for energy

2 easily hydrolysed ;

3 (energy) used in, processes / reactions ; **A** named process

4 rapid turnover ;

5 links catabolic and anabolic reactions / AW ;

6 found in, most cells / all organisms ;

7 soluble so easily moved (within cell) ;

8 ATP produced from variety of reactions ; **A** named reactions [4 max]

(c) 1 ETC / inner mitochondrial membrane / crista / stalked particles ;

2 grana / thylakoids / inner chloroplast membrane ;

3 cytoplasm / cytosol ;

4 mitochondrial matrix ; [2 max]

[Total: 8]

Q21.

6 (a) (i) phosphorylation ; [1]

(ii) lysis ; [1]

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(iii) dehydrogenation / oxidation ; *ignore reduction of NAD* [1]

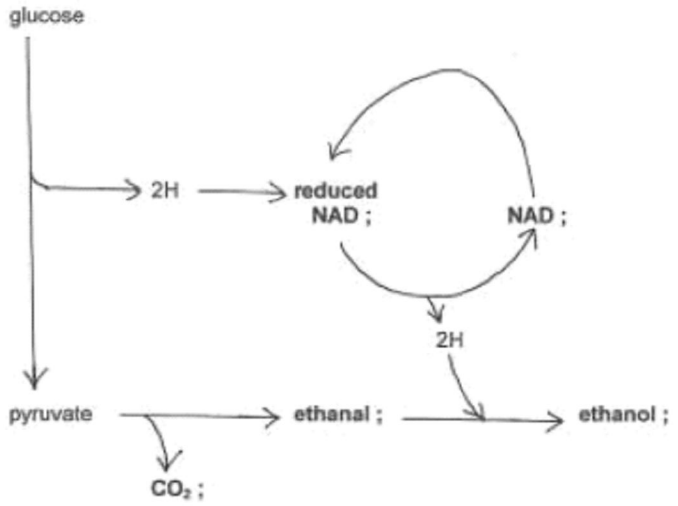
(b) provides activation energy / AW ;
for it to split / AW ; [2]

(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 ;
Y = matrix ; [2]

(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 + Pi ⟷ 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 / CO_2 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 ⟶ 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 / $NADH_2$ 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
[950×10^6 per cm^3 v 900×10^6 per cm^3] **and** [490×10^6 per cm^3 v 410×10^6 per cm^3] **or** manipulated figures

for mp2
[950×10^6 per cm^3 v 490×10^6 per cm^3] **and** [900×10^6 per cm^3 v 410×10^6 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

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 ;

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 CO_2;

7 dehydrogenation/oxidation;

8 $2CO_2$ 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 dehyrogenase;

18 reduced;

19 carries electrons;

20 and protons/H^+/H/hydrogen; **R** H_2/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	ADP + Pi → 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** H_2
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** H_2 / hydrogen
19	forms water ;	
20	ref. energy levels of carriers ;	
21	energy available to convert ADP and Pi 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 ;	
		2	raises energy level / overcomes activation energy ;	
		3	hexose bisphosphate ;	
		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	2 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 ; *accept flow diagram*	[7 max]
	(b)	12	nucleotide ;	
		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 immediate energy donor ;	
		22	link between energy yielding and energy requiring reactions / AW ;	
		23	active transport / muscle contraction / Calvin cycle / protein synthesis ;	[8 max]
				[Total: 15]

7.

9	(a)	1	acetyl CoA combines with oxaloacetate ;	
		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	oxaloacaetate regenerated ;	
		13	occurs in mitochondrial matrix ;	[9 max]
			accept diagram	
	(b)	14	coenzyme ;	
		15	for dehydrogenase ;	
		16	reduced ;	
		17	carries, electrons and protons / hydrogen / NAD	
		18	from Krebs cycle ;	
		19	and glycolysis ;	
		20	to ETC / electron carrier chain / oxidation ;	
		21	reoxidised / regenerated hydrogen removed ;	
		22	ATP produced ;	[6 max]
				[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 + Pi ⟷ 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]