12. Energy and Respiration

12.2 Respiration

Paper 4

Marking Scheme

Q1.

6(a)	an arrow through phospholipid layer in outer membrane and an arrow through phospholipid layer in inner membrane ; **R** arrows through proteins or **A**, **B**, **C** or **D**	**1**
6(b)	1 **D** = ATP synthase / ATP synthetase ; **R** ATPase 2 **A**, **B** and **C** = ETC / electron transport chain / electron carriers / electron acceptors ; *plus any **five** from:* *role of, ETC proteins / **A**, **B** and **C*** 3 electrons travel along ETC ; 4 energy released ; 5 (use energy released) to pump / actively transport, H^+ / protons, into intermembrane space ; 6 increases concentration of H^+ / protons (in intermembrane space) / creates proton gradient ; *role of **D*** 7 H^+ / protons, diffuse through, ATP synthase / **D** ; 8 (from intermembrane space) to matrix ; 9 synthesis of ATP from ADP and Pi ; 10 chemiosmosis ;	**7**

6(c)	*any **three** from:* 1 (named) enzyme for, Krebs cycle / link reaction ; 2 ETC proteins / cytochromes / electron carriers / electron acceptors / **A** / **B** / **C** ; 3 ATP synthase / **D** / described ; 4 membrane / channel / transport / carrier / structural, **proteins** ; 5 (make) tRNA / rRNA / ribosomes ;	**3**

Q2.

1(a)	<table><tr><th>stage of respiration</th><th>letter</th></tr><tr><td>glycolysis</td><td>B</td></tr><tr><td>link reaction</td><td>D</td></tr><tr><td>Krebs cycle</td><td>D</td></tr><tr><td>oxidative phosphorylation</td><td>C</td></tr></table> ;;; *3 marks if all four letters are correct* *2 marks if three letters are correct* *1 mark if one or two letters are correct*	3
1(b)	*any **four** from*: **1** oxygen is the, final / last / terminal, electron acceptor ; **2** electron transport chain / ETC, stops ; **3** less / no, protons / H^+ / hydrogen ions, move, into intermembrane space / across inner mitochondrial membrane ; **4** less / no, proton / electrochemical, gradient ; **5** less / no, protons move through ATP synthase ; **6** less / no, recycling / regeneration, of, NAD / FAD ;	4
1(c)	*any **three** from*: **1** lactate dehydrogenase ; **2** less / no, pyruvate → lactate ; **3** (so) less / no, NAD, regenerated / recycled ; **4** (so) less / no, triose phoshate / TP, → pyruvate ; **5** (so) less / no, ATP from substrate, linked / level, reactions / phosphorylation (in glycolysis) ;	3

Q3.

6(a)(i)	redox ;	1
6(a)(ii)	blue to colourless ;	1
6(b)(i)	*any **two** from:* 1 volume / mass / concentration, of yeast suspension ; 2 volume / mass / concentration, of glucose (solution) ; 3 volume / concentration, of DCPIP ; 4 AVP ; e.g. time when DCPIP is added / pH	2
6(b)(ii)	*any **three** from:* 1 the less time taken (for DCPIP) to change colour the higher the rate of respiration ; **ora** *rate increases up to 40 °C* 2 due to increase in, kinetic energy / KE ; 3 due to **more** enzyme-substrate complexes formed **or** due to **more** (successful / effective) collisions between enzymes and substrates **or more** enzyme catalysed reactions ; *rate decreases after 40 °C* 4 due to denaturation of (named respiration) enzyme ; 5 further detail ; e.g. active site shape change / optimum temperature 40 °C	3

Q4.

3(a)	<table><tr><td rowspan="2">event</td><td colspan="4">stage</td><td></td></tr><tr><td>G</td><td>LR</td><td>KC</td><td>OP</td><td></td></tr><tr><td>catabolism</td><td>✓</td><td>✓</td><td>✓</td><td>×</td><td>;</td></tr><tr><td>coenzyme is reduced or oxidised</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>;</td></tr><tr><td>a coenzyme forms a covalent bond with a respiratory intermediate</td><td>×</td><td>✓</td><td>×</td><td>×</td><td>;</td></tr><tr><td>carbon dioxide is released</td><td>×</td><td>✓</td><td>✓</td><td>×</td><td>;</td></tr></table>	**4**

Q5.

1(a)(i)	*any **one** from:* *glucose* is activated / made reactive ; becomes unstable ; cannot leave cell ; energy level increased ; concentration gradient maintained ;	**1**
1(a)(ii)	*any **one** from:* carrier / acceptor / provider, of, hydrogen (atoms) / electrons **or** provider of H ions **and** electrons ; **R** H ions alone used for redox reactions ; used to reduce, ethanal / pyruvate ;	**1**
1(a)(iii)	substrate-linked / substrate level ;	**1**

1(b)	*any **three** from:* 1 (inner) mitochondrial membrane impermeable (to pyruvate) ; 2 carrier (protein) ; **A** symport / MPC (mitochondrial pyruvate carrier) 3 lower concentration of pyruvate outside mitochondrion **ora** **or** against concentration gradient ; 4 oxygen available ; 5 ATP / energy ;	**3**
1(c)	*any **three** from:* 1 decarboxylation ; **A** description 2 dehydrogenation / oxidation, (of pyruvate) ; **A** description 3 reduced NAD produced ; 4 formation of, acetyl coenzyme A / acetyl CoA ;	**3**

Q6.

3(a)(i)	*any **two** from*: **1** oxygen / gas, supply / diffusion / transfer ; **2** to, submerged / underwater, cells / tissues / roots ; **3** for aerobic respiration ;	**2**
3(a)(ii)	*any **one** from:* **1** anaerobic respiration / ethanol fermentation ; **2** high tolerance to, alcohol / ethanol **OR** high / more, alcohol / ethanol, dehydrogenase ;	**1**

Q7.

7(a)	(pyruvate) – serine ; (oxaloacetate) – asparagine ;	**2**

Q8.

9(b)	*any **five** from*: *coenzyme A:* **1** accepts / binds to / transfers, acetyl (group) ; **2** acetyl / 2C fragment, + oxaloacetate → citrate ; **3** (joins) link reaction **and** Krebs cycle ; *NAD / FAD:* **4** transfer / transport / carry / accept / reduced by, H^+ and e^- / H (atoms) / hydrogen (atoms) ; **5** *ref.* dehydrogenation (reactions) / dehydrogenase (enzymes) ; **6** transport, to cristae / to inner mitochondrial membrane / to ETC / for oxidative phosphorylation ; **7** NAD (accepts H) in glycolysis **and** link reaction **and** Krebs cycle ;	**5**

Q9.

1(a)	**A**: carbon dioxide / CO_2 ; **B**: reduced NAD / NADH and **C**: NAD / NAD^+ ; **D**: ethanal ;	**3**
1(b)	*any **three** from:* 1 (recycles / produces) NAD ; **I** *ref. to* reduced NAD produced ; 2 *ref. to* glycolysis ; 3 *ref. to* ATP (produced) ; 4 by substrate-linked phosphorylation ;	**3**
1(c)	*any **three** from:* 1 aerenchyma provides oxygen for aerobic respiration ; 2 high concentration of ethanol dehydrogenase / high tolerance for ethanol, allows (higher rate of), ethanol fermentation / anaerobic respiration ; 3 fast growth / grow tall, so leaves, out of water / exposed to air ; 4 AVP ; e.g. ridges in submerged leaves to trap air	**3**

Q10.

5(b)	*any **five** from:* *similarities:* 1 use pyruvate ; 2 occur in, cytoplasm / cytosol ; 3 make / regenerate, NAD ; 4 redox reaction ; *differences:* 5 lactate / lactic acid, made in mammals and ethanol in yeast ; 6 one step in mammals and two steps in yeast ; 7 carbon dioxide made in yeast (not in mammals) ; 8 reversible in mammals and irreversible in yeast ;	**5**

Q11.

3(a)(i)	*any **pair** (max 2) from:* 1 cristae / folds, let inner membrane expand ; 2 when water enters (matrix), by osmosis / down water potential gradient ; 3 inner membrane (relatively) impermeable to water ; 4 (so) water does not enter (matrix), by osmosis / down water potential gradient ; 5 inner membrane moves (H^+) ions out of matrix ; 6 so less water enters (matrix), by osmosis / down water potential gradient ;	**2**
3(a)(ii)	*any **three** names plus explanations from:* 1 pyruvate, for link reaction / to bind to coenzyme A / to make acetyl (CoA) / to make reduced NAD / be dehydrogenated ; 2 oxaloacetate to, accept acetyl / make citrate ; 3 citrate to, make reduced NAD / be dehydrogenated ; 4 enzymes to catalyse, link reaction / Krebs cycle ; 5 oxygen to, accept electrons / accept protons / form water ; 6 water as a, solvent / medium for reactions ; 7 DNA / RNA, to make (named) respiratory, enzymes / proteins ;	**3**

3(a)(iii)	*any **one** from:* 1 so H^+, cannot move through / must move through ATP synthase ; 2 to maintain proton gradient ;	**1**
3(b)(i)	*any **four** from:* 1 (H atoms) split into protons and electrons ; 2 electrons, flow / move, down ETC ; 3 (releases) energy used to move H^+ to intermembrane space ; 4 more / build-up of, H^+ / positive charge, in intermembrane space ; 5 (causes / sets up) proton / electrochemical, gradient ;	**4**
3(b)(ii)	*any **two** from:* 1 (P_i) by facilitated diffusion **or** through a protein, channel / carrier ; 2 P_i and H^+ move together ; 3 (as) H^+ ions diffuse (through ATP synth(et)ase / to matrix) ;	**2**
3(b)(iii)	1 constant / sufficient / correct, supply / amount of, ADP / reactant ; 2 (so) ATP can continue to be made / so enough ATP can be made ;	**2**

Q12.

3(b)	**1** to, phosphorylate / add phosphate to, glucose ; *and any **one** from:* **2** stops glucose leaving the cell ; **3** activates glucose / makes glucose less stable ; **4** to make fructose (1,6) bi(s)phosphate ;	**2**

3(d)	*any **two** from:* **1** decarboxylated / loses carbon dioxide ; **2** dehydrogenated / oxidised / loses H ; **3** →, 2C / acetyl, (group) joins coenzyme A to make acetyl coA ;	**2**
3(e)	*any **three** from:*	**3**

	mitochondria	chloroplasts
1	oxidative phosphorylation	photophosphorylation ;
2	inner mitochondrial membrane / crista(e)	thylakoid membrane ;
3	reduced NAD / reduced FAD, give e^- / H^+	photolysis / water / PS1 / chlorophyll, give e^- / H^+ ;
4	(H^+ →) intermembrane space	(H^+ →) thylakoid, space / lumen ;
5	oxygen, final, e^- / H^+, acceptor	NADP final, e^- / H^+, acceptor ;
6	(makes) water / H_2O	(makes) reduced NADP ;

Q13.

3(a)	*any **four** from:* *accept **ora*** 1 pyruvate converted to, acetyl group / 2C group / acetyl CoA (in link reaction) ; 2 NAD needed (in link reaction) ; 3 (where) NAD becomes reduced ; 4 reduced NAD goes to ETC ; 5 ETC / oxidative phosphorylation, works if oxygen is present **or** oxygen is the final electron acceptor ; 6 (so) reduced NAD is oxidised / NAD is regenerated ;	**4**
3(b)	*any **five** from:* 1 glycolysis ; 2 phosphorylation of glucose ; 3 splitting of fructose (1,6) bi(s)phosphate / AW ; 4 (into) two, triose phosphate / TP ; 5 (TP) oxidised / dehydrogenated, to pyruvate ; 6 net 2 ATP / 4 ATP, produced ; 7 (2) reduced NAD produced ;	**5**

Q14.

2(b)(i)	**1** reduces ATP synthesis / less ADP reacts with P_i ; *any **two** from:* **2** protons <u>diffuse</u> through thermogenin ; **3** proton gradient reduced / reduces concentration of H^+ in intermembrane space ; **4** fewer protons pass through ATP synthase ;	**3**
2(b)(ii)	*any **three** from:* **1** adrenaline binds to receptor on the cell surface membrane (of brown fat cells) ; **2** G-protein / adenyl(yl) cyclase, activated ; **3** *ref. to* cAMP / second messenger, (is formed) ; **4** *ref. to* enzyme cascade / signal amplification / activation of kinase / signalling cascade ; **5** activation of lipase by phosphorylation ;	**3**

Q15.

2(a)(i)	*any **two** from:* *idea of synthesis from smaller units* **1** DNA replication / transcription ; **2** to, make / build up, (named) protein ; **3** to, make / build up, (named), lipid / triglyceride / phospholipid ; **4** to, make / build up, (named) carbohydrate / polysaccharide ; **5** phosphorylation ;	**2**
2(a)(ii)	*any **three** from:* **1** phosphorylates glucose **or** glucose → glucose / fructose / hexose, phosphate ; **2** second phosphorylation **or** glucose / fructose / hexose, phosphate → fructose / hexose, bi(s)phosphate ; **3** so glucose cannot leave the cell ; **4** activates / increases energy of / decreases stability of, glucose ;	**3**
2(b)(i)	*any **three** from:* *decreased production of ATP* **1** smaller / less steep, proton gradient ; **2** few(er) protons go through, ATP synth(et)ase / stalked particle ; *increased lipid metabolism* **3** use / burn / respire, body fat / lipid stores ; **4** as less ATP made from, glucose / food ;	**3**
2(b)(ii)	*any **two** from:* **1** more / faster / increased, (rate of) glycolysis ; **2** oxygen, decreased / used faster / shortage ; **3** (so) more / increased, <u>anaerobic</u> respiration ;	**2**
2(b)(iii)	*any one from:* energy from, reduced NAD / ETC, released as heat ; energy not used to join ADP and Pi so released as heat ;	**1**

Q16.

6(b)(i)	<table><tr><th>statement</th><th>letter</th></tr><tr><td>the site of the Krebs Cycle</td><td>**A**</td></tr><tr><td>a phospholipid bilayer impermeable to H+ ions</td><td>**E / D**</td></tr><tr><td>the site of translation</td><td>**C**</td></tr></table> ;; *all correct = 2 marks* *1 or 2 correct = 1 mark*	**2**
6b(ii)	$(2 \times \pi \times 0.36^2) + (2 \times \pi \times 0.36 \times 5.25)$ **or** $2\pi \times 0.36\ (0.36 + 5.25)$; 12.7 **or** 12.68 **or** 12.69 ; *accept 3.14 or π in workings*	**2**
6(b)(iii)	1 (more cristae results in) **more**, ETC / (named) carrier proteins / ATP synthase ; **or** (more cristae results in) **more**, oxidative phosphorylation / chemiosmosis / ATP synthesis ; 2 (because) cardiac muscle must undergo continuous contractions / AW ;	**2**

Q17.

7(c)(i)	*any **four** from:* 1 ETC / electron transport chain, functions as normal ; 2 H^+ / protons, pumped into intermembrane space ; 3 proton gradient established ; 4 most, H^+ / protons, diffuse through, DNP ; 5 into matrix ; 6 less / fewer, H^+ / protons, pass through ATP synthase ; 7 less ATP produced ;	**4**
7(c)(ii)	*any **two** from:* 1 tiredness ; 2 weight loss ; 3 increased, heart rate / breathing rate	**2**

Q18.

6(a)	carbon dioxide ;	1
6(b)	*any **one** from:* 1 triose phosphate dehydrogenated ; 2 reduced NAD, made / released ;	1
6(c)(i)	*(glycolysis) + (Krebs)* *(ATP + reduced NAD) + (ATP + reduced NAD + reduced FAD)* **(4 – 2)** + (4 × 3) + 2 + (6 × 3) + (2 × 2) **OR** 2 + 12 + 2 + 18 + 4 ; 38 ;	2

6(c)(ii)	*any **two** from:* 1 ATP / energy, used to transport, pyruvate / reduced NAD / products of glycolysis, into (named part of) mitochondria ; 2 some protons leak from intermembrane space ; 3 some energy lost as heat ; 4 glucose may not be completely broken down / some intermediates are used in different metabolic processes ; 5 reduced NAD may be used for other (metabolic) reactions ;	2
6(d)	*any **three** from:* 1 coenzymes ; 2 help / for, dehydrogenases / dehydrogenation (reactions) ; 3 *ref. to* glycolysis / link reaction / Krebs cycle ; 4 carry / transfer / transport / bring, hydrogens / H ; 5 to, ETC / inner mitochondrial membrane / crista(e) ;	3

6(e)	*any **three** from:* 1 less / no, energy (release from electron transfer / ETC) ; 2 less / no, chemiosmosis ; 3 fewer / no, protons, move / pumped, to intermembrane space ; 4 less (steep) / no, proton gradient ; 5 fewer / no, protons, move / diffuse, through ATP synth(et)ase ; 6 less / no, ATP synthesised ;	3

Q19.

4(a)	1 less / no, ATP made ; 2 (so) poor muscle contraction / AW *or* (so) reduced impulse transmission ;	**2**

Q20.

6(a)(i)	anaerobic conditions / no oxygen available / little oxygen available ;	**1**
6(a)(ii)	carbon dioxide ;	**1**
6(a)(iii)	dehydrogenation ; decarboxylation ;	**2**
6(a)(iv)	red blood cell / erythrocyte ; (so) no mitochondria ;	**2**
6(a)(v)	substrate-linked phosphorylation ;	**1**

Q21.

7(b)	*any **three** from:* 1 aerenchyma so oxygen can reach submerged, parts / roots ; 2 ridges on underwater leaves to hold air close to, leaf surface / stomata ; 3 grow taller to keep leaves and flowers above water level ; 4 high tolerance to ethanol so roots can respire anaerobically ; 5 produce more ethanol dehydrogenase to breakdown ethanol from anaerobic respiration ;	**3**

Q22.

7(a)	**A** ; **E** ; **C / D** ; **B** ; **H** ; **D** ;	**6**
7(b)	lactate, converted / oxidised ; to, pyruvate / glucose / glycogen ; haemoglobin / myoglobin, re-oxygenated ;	**2**

Q23.

8	NAD / FAD / coenzyme ; intermembrane space ; cristae / inner membrane ; diffuse ; ATP synthase / ATP synthetase / stalked particle ; oxygen ;	**6**

Q24.

8(a)	<table><tr><th>correct order</th><th>letter of stage</th></tr><tr><td>1</td><td>**V**</td></tr><tr><td>2</td><td>**S**</td></tr><tr><td>3</td><td>**U**</td></tr><tr><td>4</td><td>**W**</td></tr><tr><td>5</td><td>**R**</td></tr><tr><td>6</td><td>**Q**</td></tr><tr><td>7</td><td>**X**</td></tr><tr><td>8</td><td>**T**</td></tr></table> 6 correct = 4 marks 4/5 correct = 3 marks 2/3 correct = 2 marks 1 correct = 1 mark ;;;;	**4**
8(b)	*ATP synthase* - cristae / inner membrane ; *Krebs cycle* - matrix ; *electron transport chain* - cristae / inner membrane ; *coenzyme A* - matrix ; *pyruvate* - matrix ;	**5**

Q25.

4(a)	<table><tr><th>correct order</th><th>letter of stage</th></tr><tr><td>1</td><td>E</td></tr><tr><td>2</td><td>I</td></tr><tr><td>3</td><td>F</td></tr><tr><td>4</td><td>A</td></tr><tr><td>5</td><td>G</td></tr><tr><td>6</td><td>J</td></tr><tr><td>7</td><td>B</td></tr><tr><td>8</td><td>K</td></tr><tr><td>9</td><td>C/H</td></tr><tr><td>10</td><td>H/C</td></tr><tr><td>11</td><td>D</td></tr></table> ; ; ; ;	4
4(b)	*any **four** from:* 1 acts as, coenzyme / cofactor ; 2 to dehydrogenase / in dehydrogenation ; 3 takes / carries / delivers / releases / gives, hydrogen / H (atoms) ; 4 to, (carrier on) ETC / inner mitochondrial membrane / cristae **or** for, ATP production / oxidative phosphorylation ; 5 *ref. to* redox / reduction and oxidation / reduced **and** oxidised ; 6 2.5 / 3, ATP per reduced NAD ;	4

4(c)(i)	6 ;	1

Q26.

6(a)	link reaction ; matrix of mitochondrion ; **2** and **3** ; substrate–linked phosphorylation ; **A** substrate-level phosphorylation (**Q** =) NAD and (**R**=) FAD ;	5
6(b)	reduced, NAD / FAD, to ETC ; **A** description *ref. to* oxidative phosphorylation / chemiosmosis ; **A** description	2

Q27.

6(a)	<table><tr><th>compound or structure</th><th>location</th></tr><tr><td>ATP synthase</td><td>P</td></tr><tr><td>acetyl CoA</td><td>Q</td></tr><tr><td>phospholipid bilayer</td><td>P</td></tr><tr><td>oxaloacetate</td><td>Q</td></tr></table> ;;;	3
6(b)(i)	$16(.00) \times 10^{-3}$;	1
6(b)(ii)	*any two from:* mitochondria / respiration, produce(s) ATP ; heart / cardiac muscle (cell), is more active OR needs more, energy / ATP ; heart / cardiac muscle, (cell) contracts ; **ora**	2
6(b)(iii)	mitochondria vary, in size / in surface area of inner membrane ;	1

Q28.

6(a)(i)	cytoplasm ;	1
6(a)(ii)	*phosphorylation:* **1** (and) **3** ; *oxidation:* **5** ; *reaction in step 5:* substrate-linked phosphorylation ;	3
6(b)	*any two from* *cancer cells* **1** need / use, more glucose ; **2** need / use, less oxygen ; **3** get, little energy / 2 ATP / small amount of ATP, per glucose (molecule) / from glycolysis ;	2