BIOWELSH WORKSHEET FOR WJEC GCE A LEVEL BIOLOGY
UNIT 3 – ENERGY, HOMEOSTASIS AND THE ENVIRONMENT
TOPIC 3.3 RESPIRATION: WORKSHEET 1 (BW-A2-3.3-W1) MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Mark in red ink. One tick equals one mark, except in the extended response question, where a level of response scheme is used.

Write each question total in the box at the end of the question, and copy the totals onto the grid on the front cover of the worksheet. Add them to give the worksheet total out of 149.

Marking rules

Look at all of the work. Where the scheme says working is needed, the working must be seen. Mark crossed-out work if it has not been replaced. Give credit for correct, relevant answers that are not listed in the scheme.

Extended response question

Read the whole answer first. Decide which level descriptor fits the answer best, judging the overall quality. Then choose the mark within the level: the top mark when the answer matches both the content and the communication statements well, the middle mark when most of the content is there and the communication statement is partly met, and the bottom mark when only the content statements are matched.

Marking abbreviations

cao	=	correct answer only
ecf	=	error carried forward
bod	=	benefit of doubt
ORA	=	or reverse argument
owtte	=	or words to that effect

Notation: / separates alternatives; { } groups alternatives within a point; words in ( ) are not needed for the mark; underlined words are essential; (1) is one mark.

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)			W = 6, X = 3, Y = 3, Z = 2 All four correct = 2 marks Two or three correct = 1 mark		2		2		
	(b)			Y pyruvate / pyruvic acid (1) Z acetyl coenzyme A / acetyl CoA (1) Reject acetic acid for Z	2			2		
	(c)			Phosphorylation (of glucose) / adds phosphate groups to glucose (1) {Makes glucose more reactive / lowers activation energy} so that it can be split into two {triose phosphate / 3C molecules} (1) Allow: traps glucose in the cell	1	1		2		
	(d)			2 (1) (4 made − 2 used) cao		1		1	1	
	(e)			Any three (×1) from: • Y enters the {mitochondrion / matrix} (1) • Decarboxylation / CO_2 removed (1) • Dehydrogenation / oxidation / hydrogen removed (1) • Hydrogen accepted by NAD to form reduced NAD (1) • (2C) acetyl group combines with coenzyme A to form acetyl CoA (1)	3			3		
				Question 1 total	6	4	0	10	1	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)			A crista / cristae / (fold of) inner mitochondrial membrane (1) B matrix (1) Reject stroma, thylakoid	2			2		
	(b)			440 to 520 nm (2) Award 1 mark for measured length of X–Y ÷ measured length of scale bar × 200 Correct answer with no working = 2 marks		2		2	2	
	(c)	(i)		Heart (muscle) contracts continuously / never rests (1) So needs a constant supply of ATP from aerobic respiration / Krebs cycle and ETC take place in mitochondria (1) Ignore 'energy is made'		2		2		
		(ii)		Any one (×1) from: • Many metabolic reactions need ATP (1) • Named example: protein synthesis / detoxification / active transport / making urea / making glycogen (1)		1		1		
	(d)			By glycolysis (in the cytoplasm) / anaerobic respiration (1) Pyruvate converted to lactate to regenerate NAD (1) Advantage: do not use the oxygen they carry / more space for haemoglobin (1)	1	2		3		
				Question 2 total	3	7	0	10	2	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)			Matrix of the mitochondrion (1) Reject mitochondrion alone	1			1		
	(b)			Steps 1 and 2 (1) Number of carbon atoms decreases (6C → 5C → 4C) / decarboxylation occurs (1)		2		2		
	(c)			reduced NAD 6, reduced FAD 2, ATP 2, carbon dioxide 4 All four correct = 2 marks Two or three correct = 1 mark Allow ecf if all four are halved (one turn of the cycle) = 1 mark		2		2		
	(d)			It combines with / accepts the {acetyl group / 2C group} (to form the 6C compound) (1) So the cycle can continue / only a small amount of 4C compound is needed (1)	1	1		2		
	(e)			Oxygen is the final (electron / hydrogen) acceptor (in the ETC) (1) (Without oxygen) the electron transport chain stops / reduced NAD and reduced FAD are not oxidised (1) No {NAD / FAD} available to accept hydrogen in the Krebs cycle / dehydrogenation stops (1)		3		3		
				Question 3 total	2	8	0	10	0	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
4	(a)			Inner mitochondrial membrane (1) P intermembrane space and Q matrix (1) Both regions needed for the second mark	2			2		
	(b)			Arrow through L from P (intermembrane space) to Q (matrix) and labelled H (1)		1		1		
	(c)			Any four (×1) from: • Electrons passed from carrier to carrier / along the chain (in a series of redox reactions) (1) • Electrons lose energy as they move along the chain (1) • Energy used by proton pumps / **J** to pump protons into the intermembrane space / P (1) • Creates a proton gradient / electrochemical gradient (across the inner membrane) (1) • Protons diffuse back through ATP synthetase / **L** / chemiosmosis (1) • ATP synthetase catalyses ADP + P_i → ATP (1)	4			4		
	(d)			To maintain the proton gradient (1) So that protons only return through ATP synthetase and energy is used to make ATP (rather than being lost as heat) (1)		2		2		
	(e)			Final {electron / hydrogen} acceptor / combines with electrons and protons to form water (1) Final must be stated	1			1		
				Question 4 total	7	3	0	10	0	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)			12 (1) % (of starting value) min^{-1} (1) (94 − 64) ÷ 2.5 = 12 Allow ±1 on readings		2		2	2	
	(b)			ADP is a substrate for ATP synthetase / ATP synthesis can take place (1) Protons flow back through ATP synthetase so the proton gradient falls, allowing electron transport / proton pumping to speed up, so more oxygen is used as the final acceptor (1)		2		2		
	(c)			Oxygen uptake almost stops / rate falls to about 1 % min^{-1} (1) Protons cannot return to the matrix so the proton gradient becomes very steep (1) Proton pumps cannot pump against the gradient so electron transport stops / oxygen no longer accepts electrons (1)		1	2	3		
	(d)			Any three (×1) from: • Protons return to the matrix without passing through ATP synthetase (1) • Proton gradient is lost / reduced (1) • Proton pumping / electron transport can continue (1) • Oxygen still used as the final electron acceptor (1) • Energy released as heat (instead of ATP) (1)		1	2	3		
	(e)			Less ATP made per molecule of respiratory substrate (1) So more {fat / glucose / stored substrate} is respired to meet the demand for ATP (1) Allow energy lost as heat			2	2		
				Question 5 total	0	6	6	12	2	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)			38 (2) Award 1 mark for (10 × 3) + (2 × 2) = 34 / 4 ATP from substrate-level phosphorylation shown		2		2	2	
	(b)			40.4 (%) (2) Award 1 mark for 38 × 30.6 = 1162.8 (kJ) Allow ecf from (a)		2		2	2	
	(c)			2.1 (%) (1) (2 × 30.6 ÷ 2880 × 100)		1		1	1	
	(d)			Released / lost as heat (1) Maintains body temperature / keeps enzymes near their optimum temperature (1)	1	1		2		
	(e)			Any two (×1) from: • Some protons leak back across the inner membrane (not through ATP synthetase) (1) • ATP is used to transport pyruvate / ADP / phosphate into the mitochondrion (1) • Reduced NAD from glycolysis produces fewer ATP / energy used to move it into the mitochondrion (1) • Some energy from the proton gradient is released as heat (1)			2	2		
				Question 6 total	1	6	2	9	5	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)			Increases for the first 3 days then {levels off / stays constant} (1) Use of figures, e.g. rises from 1 au to about 10 au / increases about tenfold (1)		2		2		
	(b)			Regenerates NAD / oxidises reduced NAD (1) NAD needed to accept hydrogen in glycolysis (1) So glycolysis continues, producing (a net) 2 ATP per glucose (1)		3		3		
	(c)			Pyruvate (1) Carbon dioxide (1)	2			2		
	(d)			Oxygen diffuses from the {leaves / air} to the roots (1) So root cells can respire aerobically, producing more ATP (for active uptake of ions / growth) (1)		1	1	2		
	(e)			Any one (×1) from: • Ethanol is toxic / builds up to toxic levels (1) • Too little ATP for active uptake of mineral ions / growth (1)			1	1		
				Question 7 total	2	6	2	10	0	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)	(i)		9.1 (cm^3) at 40 °C (1)			1	1		1
		(ii)		30 °C: 8.0 (1) 40 °C: 14.9 (1) Must be to 1 decimal place		2		2	2	2
	(b)			Independent: temperature (1) Controlled, any two for 1 mark: concentration / volume of glucose; mass / volume / concentration of yeast; pH / use of buffer; volume of suspension; time allowed to equilibrate (1)			2	2		2
	(c)			So that the suspension reaches the temperature of the water bath (1)			1	1		1
	(d)			Rate of respiration / volume of CO_2 decreases (1) (Respiratory) enzymes are denatured / hydrogen bonds broken (1) Active site changes shape so fewer enzyme–substrate complexes form (1)	1	2		3		
	(e)			Volume of CO_2 collected is lower than the volume produced / results are underestimates (1) Improvement: saturate the suspension with CO_2 before starting / use a CO_2 sensor or data logger (1)			2	2		2
				Question 8 total	1	4	6	11	2	8

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)			1.0 %: 4.2 (1) 2.0 %: 7.7 (1)		2		2	2	
	(b)			Axes correct way round with labels and units: x = concentration of glucose / %; y = rate / 1000 ÷ time (1) Suitable linear scales using more than half of the grid (1) All points plotted correctly ± half a small square (1) Points joined with ruled straight lines (1)		2	2	4	4	4
	(c)			Dehydrogenase enzymes remove hydrogen from glucose / respiratory intermediates (1) Methylene blue accepts the hydrogen / is reduced (instead of NAD) (1)	1	1		2		
	(d)			Glucose is no longer the limiting factor (1) (Dehydrogenase) enzyme active sites are saturated / enzyme concentration is limiting (1)		2		2		
	(e)			Shaking dissolves oxygen, which would re-oxidise the methylene blue / turn it blue again (1)			1	1		1
				Question 9 total	1	7	3	11	6	5

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)			Potassium hydroxide absorbs carbon dioxide (1) Oxygen is absorbed / used in respiration so the {volume / pressure} of gas in the tube decreases (1)		2		2		1
	(b)			89.5 (mm^3 $hour^{-1}$) (3) Award 2 marks for 29.8 (mm^3 in 20 minutes) Award 1 mark for $3.14 \times 0.5^2 \times 38$ / 0.785×38		3		3	3	
	(c)			0.71 (2) Award 1 mark for carbon dioxide produced = 38 − 11 = 27 (mm of movement)		1	1	2	2	
	(d)			Lipid / fat / oil (1) RQ is about 0.7 / less than 1 / lipids need more oxygen for each carbon dioxide released (1) Allow ecf from (c)		1	1	2		
	(e)			Same apparatus with {glass beads / dead (boiled) seeds} of the same volume / mass (1)			1	1		1
				Question 10 total	0	7	3	10	5	2

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	(a)			A hydrolysis (1) C deamination (1)	2			2		
	(b)			Liver (1) Converted to ammonia and then to urea (1)	2			2		
	(c)			8 (1)		1		1	1	
	(d)			Lipids contain more hydrogen atoms (per carbon / per gram) (1) So more reduced NAD / reduced FAD, more protons pumped and more ATP made (in the electron transport chain) (1)		2		2		
	(e)			Fat releases more than twice the energy per gram (39 compared with 17 kJ g^{-1}) (1) So less mass needs to be carried for the same energy / glycogen is stored with water, adding mass (1)			2	2		
				Question 11 total	4	3	2	9	1	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12	(a)			D adenine, E ribose, F phosphate (group) All three correct = 2 marks Two correct = 1 mark	2			2		
	(b)			ATP synthetase / ATP synthase (1)	1			1		
	(c)			Any three (×1) from: • Hydrolysis of ATP releases a small, manageable amount of energy / 30.6 kJ mol^{-1} (1) • Energy released in a single step / one reaction (1) • Quickly released / quickly regenerated from ADP and P_i (1) • Soluble / easily moved around the cell (1) • Used in all cells / universal (1)	3			3		
	(d)			41.7 / 42 (2) Award 1 mark for 50 000 ÷ 50 = 1000 (times per day)		2		2	2	
	(e)			ATP is unstable / is readily hydrolysed (1) ATP stores little energy per molecule / large mass needed / glycogen and fat store more energy per gram (1)			2	2		
				Question 12 total	6	2	2	10	2	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13	(a)			With malate, oxygen uptake falls from 80 to 4 au / by 95 % (1) With succinate, oxygen uptake is hardly affected / falls only from 95 to 92 au (1)		2		2		
	(b)			Reduced FAD passes electrons to the chain after the first pump / after the blocked step (1) So electrons still flow along the chain to oxygen (1) (But) fewer protons are pumped so less ATP is made (2 ATP rather than 3) (1)		1	2	3		
	(c)			Electrons cannot be passed to oxygen / oxygen cannot act as the final electron acceptor (1) So the whole chain stops, whichever carrier the electrons enter at (1)		2		2		
	(d)			Glycolysis produces only 2 ATP per glucose / too little ATP for {heart / brain / active tissues} (1) Lactate builds up / blood pH falls (1)			2	2		
				Question 13 total	0	5	4	9	0	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
14	(a)			Population with oxygen grows faster / steeper curve (1) Population with oxygen reaches a higher final density / 2.4 compared with 0.6 au / four times higher (1)		2		2		
	(b)			Aerobic respiration produces up to 38 ATP per glucose but anaerobic respiration produces only 2 (1) So more energy is available for growth / protein synthesis / cell division from each glucose molecule (1) The same (limited) amount of glucose supports a larger population (1)		3		3		
	(c)			Cell surface membrane / plasma membrane (1) Reject cell wall	1			1		
	(d)			Any two (×1) from: • Glucose / nutrients used up (1) • Build-up of toxic waste products (1) • Oxygen became limiting (as the population became dense) (1)			2	2		
	(e)			Anaerobic respiration / fermentation produces acids, e.g. lactate / lactic acid (1)			1	1		
				Question 14 total	1	5	3	9	0	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
15				**Indicative content** Allow correct use of the term oxygen debt.	4	3	2	9		
				A Electron transport chain and oxygen A1 Oxygen is the final electron / hydrogen acceptor A2 Combines with electrons and protons to form water A3 Without oxygen, electrons cannot leave the chain so electron transport stops A4 Proton pumping stops / no proton gradient, so no ATP from ATP synthetase (chemiosmosis) A5 Reduced NAD and FAD are not oxidised, so the Krebs cycle and link reaction stop						
				B Anaerobic respiration and the energy budget B1 Glycolysis continues in the cytoplasm B2 Pyruvate is reduced to lactate by reduced NAD B3 Regenerating NAD so that glycolysis can continue B4 Only 2 ATP per glucose (compared with up to 38 aerobically) B5 Efficiency falls from about 40 % to about 2 % B6 So glucose / glycogen stores are used up much faster						
				C Using Graph 15.1 C1 Up to about 20 minutes peak lactate stays at about 1.5 to 2 mmol dm^{-3} / resting level C2 So these dives are fully aerobic, using stored oxygen (in myoglobin / blood) C3 After about 20 minutes lactate rises steeply, to about 15 mmol dm^{-3} at 55 minutes C4 Longer dives use anaerobic respiration / exceed the aerobic dive limit C5 Lactate must be removed at the surface, which needs oxygen (oxidised back to pyruvate or converted to glucose in the liver) C6 So the seal must rest / breathe at the surface for longer before it can dive again; short aerobic dives waste less time and glycogen						

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				7-9 marks Indicative content of this level is detailed information from all three lists. The candidate constructs an articulate, integrated account, correctly linking relevant points in a logical sequence. The answer fully addresses the question with no irrelevant inclusions or significant omissions. Scientific conventions and vocabulary are used appropriately and accurately.						
				4-6 marks Indicative content of this level is detailed information from two of the lists, or less detail from all three. The candidate constructs an account correctly linking some relevant points, showing some reasoning. The answer addresses the question with some omissions. Scientific conventions and vocabulary are usually used appropriately and accurately.						
				1-3 marks Indicative content of this level is some information from at least one of the lists, or a little information from more than one. The candidate makes some relevant points, showing limited reasoning. The answer addresses the question with significant omissions. Use of scientific conventions and vocabulary is limited.						
				0 marks The candidate does not make any attempt or give a relevant answer worthy of credit.						
				Question 15 total	4	3	2	9	0	0

UNIT 3: ENERGY, HOMEOSTASIS AND THE ENVIRONMENT, TOPIC 3.3

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	6	4	0	10	1	0
2	3	7	0	10	2	0
3	2	8	0	10	0	0
4	7	3	0	10	0	0
5	0	6	6	12	2	0
6	1	6	2	9	5	0
7	2	6	2	10	0	0
8	1	4	6	11	2	8
9	1	7	3	11	6	5
10	0	7	3	10	5	2
11	4	3	2	9	1	0
12	6	2	2	10	2	0
13	0	5	4	9	0	0
14	1	5	3	9	0	0
15	4	3	2	9	0	0
TOTAL	**38**	**76**	**35**	**149**	**26**	**15**