

Name	Date started	Target end date
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GCE A LEVEL – BIOLOGY UNIT 3 QUESTION PACK

1074 (Legacy BY4) + 1075 (Legacy BY5) · New spec Unit 3 Topic 5 · A2 unit, first sat 2017, 90 marks, 2h paper

REVISE

.wales

BIOLOGY – UNIT 3 · RESPIRATION – KREBS, OXIDATIVE PHOSPHORYLATION & ANAEROBIC

3.3 Respiration – the Krebs cycle, the electron transport chain, chemiosmosis and anaerobic respiration

The Krebs cycle in the matrix (citrate, oxaloacetate, decarboxylations, reduction of NAD and FAD), the inner-membrane electron transport chain, proton-pumping and chemiosmosis on ATP synthase, the total aerobic yield of ~38 ATP, plus anaerobic alternatives (lactate fermentation, alcoholic fermentation) and respiratory quotient (RQ) calculations.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~1 h 49 min

Derived from the legacy BY4 / BY5 papers' pace of ~1.3 min/mark, padded for long-prose answers (68 marks over 5 questions).

You are advised to **not** attempt to complete all of this in one sitting.

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC BY4 (and BY5, where relevant) papers (2008 modular spec, 2011–2017) that maps onto new-spec A2 Unit 3 Topic 5 (3.3).

Questions are ordered by source paper date.

INSTRUCTIONS

Use black ink or black ball-point pen. Show all working – quality of written communication will affect marks. A calculator is allowed. Diagrams included in answers must be fully annotated.

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Q	Source	Max	Mark	Q	Source	Max	Mark
1	BY4 Jun 13 Q5	15		4	BY4 Jan 14 Q5	12	
2	BY4 Jun 14 Q6	16		5	BY4 Jan 14 Q6	12	
3	BY4 Jan 13 Q4	13					
Total						68	

Respiration – Krebs, Oxidative Phosphorylation & Anaerobic – what the new spec asks

WJEC GCE A Level Biology (from 2015) · Unit 3: Energy, Homeostasis & the Environment · Topic 3.3.

Krebs cycle

- In the matrix of the mitochondrion.
- Acetyl (2C) + oxaloacetate (4C) → citrate (6C).
- Per acetyl: 2 CO₂, 3 NADH, 1 FADH₂, 1 ATP (substrate-level).

Electron transport chain

- Embedded in the inner mitochondrial membrane (cristae).
- Reduced NAD / FAD donate electrons; pass along carriers.
- Energy released pumps H⁺ into the intermembrane space.

Chemiosmosis & ATP synthase

- H⁺ gradient drives flow back through ATP synthase.
- Each NADH yields ~3 ATP, each FADH₂ yields ~2 ATP.
- O₂ is the final electron acceptor → H₂O.

Anaerobic respiration & RQ

- Animal: pyruvate → lactate by lactate dehydrogenase; regenerates NAD.
- Yeast: pyruvate → ethanol + CO₂ (alcoholic fermentation).
- RQ = CO₂ produced / O₂ used: 1.0 carb, ~0.7 lipid, ~0.9 protein.

Respiration – Krebs, Oxidative Phosphorylation & Anaerobic in one page

Quick-reference notes – revisit before each question.

Krebs

Acetyl (2C) + oxaloacetate (4C) → citrate (6C).

Two decarboxylations → 2 CO₂.

Per turn: 3 NADH, 1 FADH₂, 1 ATP (substrate-level), regenerates OAA.

ETC carriers

NADH dehydrogenase, ubiquinone, cytochromes, cytochrome oxidase.

Electrons lose energy stepwise.

Energy pumps H⁺ across inner membrane.

Chemiosmosis

High H⁺ in intermembrane space.

Flow back through ATP synthase → ATP.

One full turn = ~3 ATP per NADH, ~2 per FADH₂.

O₂ as acceptor

Final electron acceptor at cytochrome oxidase.



Without O₂, ETC stops ⇒ NADH builds up.

Anaerobic

Animal: pyruvate → lactate; regenerates NAD via lactate dehydrogenase.

Yeast: pyruvate → ethanol + CO₂.

Glycolysis continues – only 2 ATP per glucose.

RQ

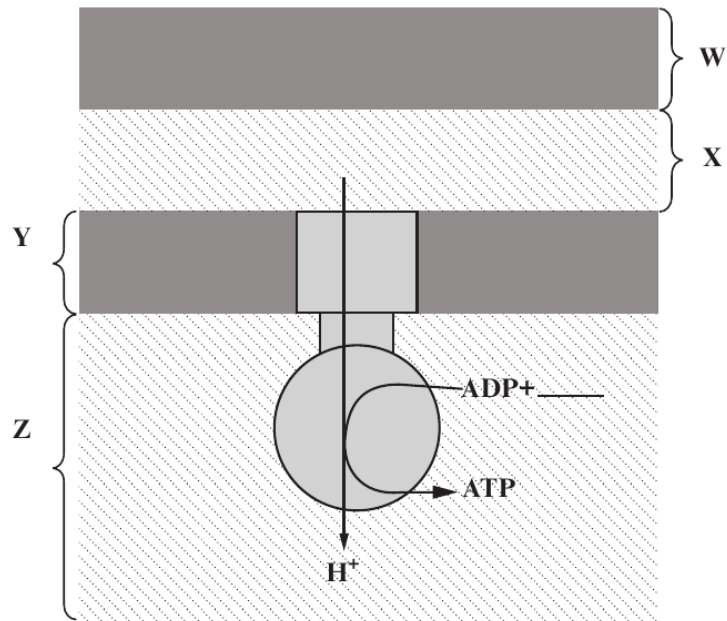
RQ = CO₂ produced / O₂ used.

Carbohydrate ~1.0; protein ~0.9; lipid ~0.7.

Anaerobic respiration produces CO₂ without O₂ use ⇒ RQ > 1.

5. Respiration results in the production of ATP in cells. Production of ATP in the mitochondrion is catalysed by an enzyme and requires energy supplied by a proton gradient. The diagram below represents a model of the ATP synthetase complex.

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(a) (i) On the diagram above, complete the equation for the production of ATP. [1]

(ii) Name parts **W** and **Z** shown on the diagram above. [2]

W **Z**

(iii) State whether the H^+ concentration is highest in part **W**, **X**, **Y** or **Z**. [1]

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(b) The proton gradient can be maintained as long as reduced NAD is available in the mitochondrion. Explain the reasons for reduced NAD being required to maintain a proton gradient. [2]

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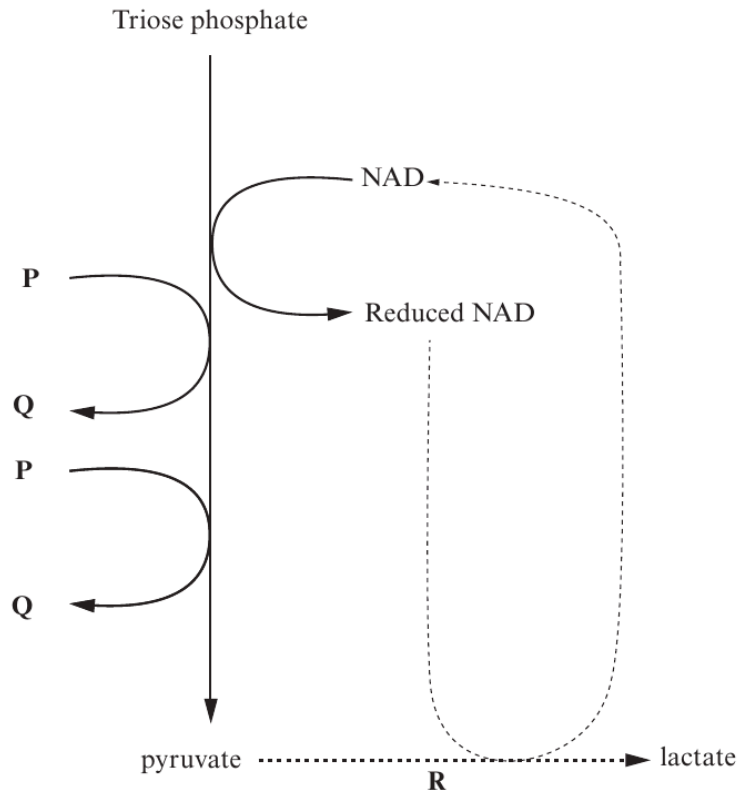
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(c) The diagram below shows one stage of respiration in which reduced NAD is produced.



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(i) Name chemicals **P** and **Q**. [1]

P **Q**

(ii) Where in the cell do the reactions shown in the diagram above occur? [1]

(iii) Outline the pathway for the production of triose phosphate in glycolysis. [3]

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- (d) (i) The reaction labelled **R** on the diagram on the previous page occurs in humans when there are **anaerobic** conditions in a tissue. Explain the **biochemical** reasons for carrying out the reaction, despite the fact that lactate is toxic in high concentrations. [3]

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- (ii) Reaction **R** sometimes occurs in muscle fibres when a short burst of very rapid ATP production is needed. Suggest a reason for this. [1]

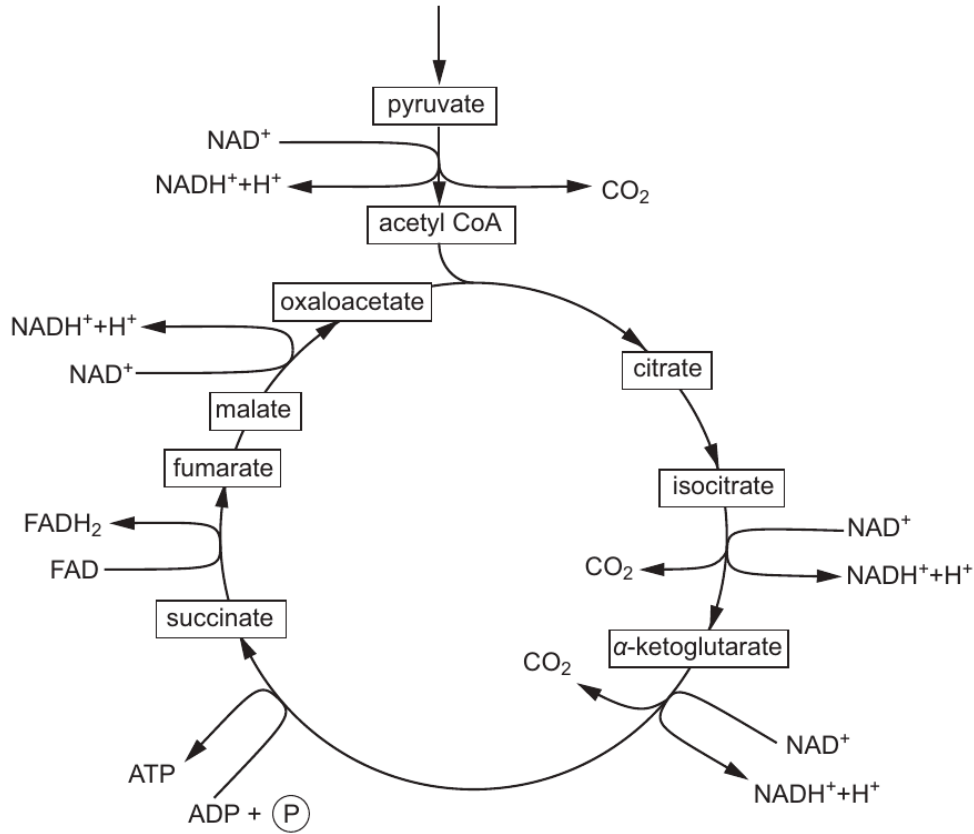
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6. The detailed diagram below shows the link reaction and Krebs cycle. Most of the intermediates involved are named.



- (a) (i) Using the diagram above, and your own knowledge, determine how many carbons there are in the following Krebs cycle intermediates. [1]

citrate

α-ketoglutarate

succinate

- (ii) Explain precisely how you have arrived at these figures. [2]

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Examiner
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- (b) Briefly describe how reduced FAD and reduced NAD are used to create an electrochemical gradient. [4]

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In patients with a suspected mitochondrial disorder a minimally invasive tissue biopsy provides the best opportunity to examine mitochondrial function, freezing the sample immediately after collection.
In addition to activity measurements of individual enzymes, analysis of mitochondrial respiration and ATP production rates are performed. This includes the measurement of mitochondrial oxygen consumption in the presence of different substrates, such as pyruvate and α -ketoglutarate. Analysis may show increased levels of a Krebs cycle intermediate, such as malate and succinate.
Defects in mitochondrial ATP synthesis may lead to high lactate levels in blood.
J Inherit Metab Dis. 2011 April; 34(2): 283–292.

- (c) Name the **two** enzyme **types** involved in the conversion of pyruvate to acetyl CoA. [2]

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Using the diagram opposite, the text above and your own knowledge, answer the following questions.

- (d) Suggest a suitable tissue to examine mitochondrial function and explain why you have chosen this tissue with respect to patient safety. [2]

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- (e) What could be deduced if the oxygen consumption was low with the pyruvate as a substrate but high with α -ketoglutarate as a substrate? [2]

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- (f) What could be deduced if there was a build up of any one of the Krebs cycle intermediates? [1]

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- (g) Explain why there is a raised blood lactate level in many patients with mitochondrial disease. [2]

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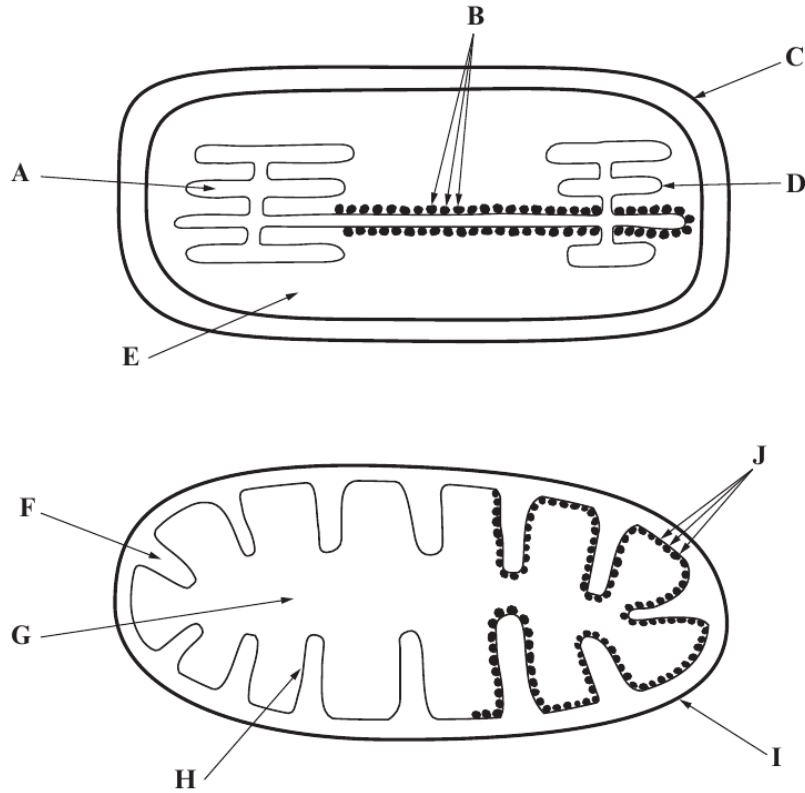
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4. The diagrams below show the main structures in mitochondria and chloroplasts that are involved in the production of ATP.

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(a) Use a letter from **each** diagram to identify where the following stages of ATP production take place in chloroplasts and mitochondria. [8]

Stage in ATP Production	Chloroplasts	Mitochondria
Protons are pumped across a membrane by proton pumps fuelled by electron energy		
A high concentration of hydrogen ions builds up		
Protons flow down a concentration gradient and provide the energy for ATP synthesis		
Free electrons are taken up by a final electron acceptor		



(b) (i) Explain the importance of ATP in cells.

[3]

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(ii) Explain why ATP is sometimes called the *universal energy currency*.

[2]

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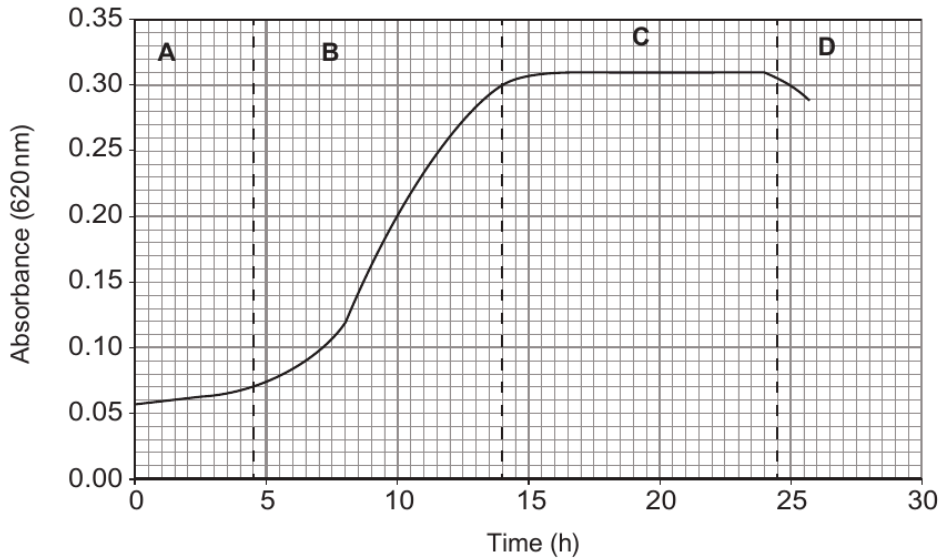
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5. Dried yeast cells were added to sterile culture medium and grown under **anaerobic** conditions. Glucose was present in excess of requirements for 30 hours of culture. The following growth curve was obtained.



- (a) Name the stages of the growth curve of yeast shown on the graph above and explain **precisely** what is occurring in the culture at **each** of these stages. [8]

	<i>Name of stage</i>	<i>Explanation</i>
A		
B		
C		
D		



(b) Describe the metabolism of pyruvate in the anaerobic respiration of glucose in yeast.

[4]

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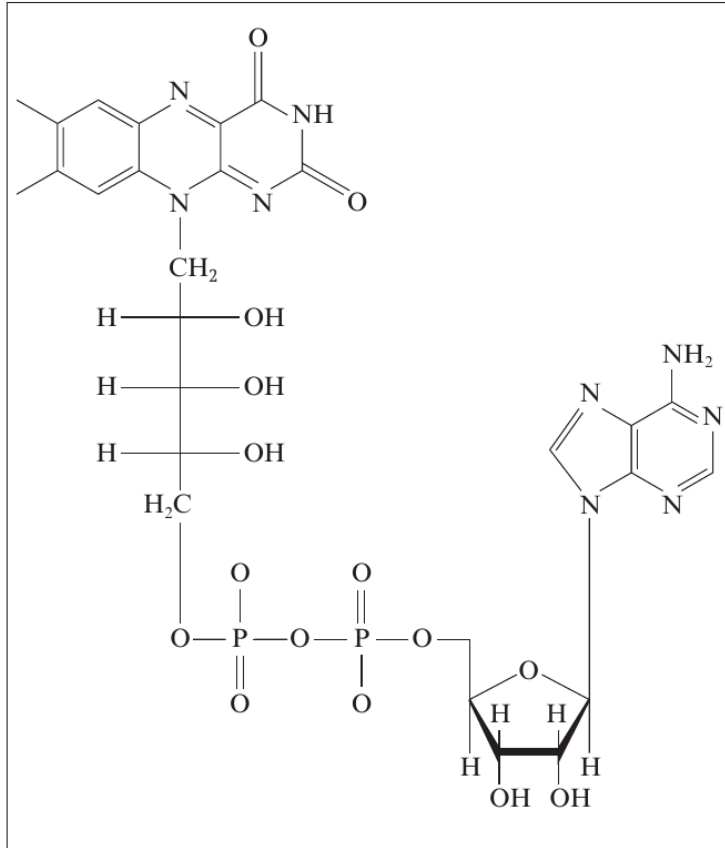
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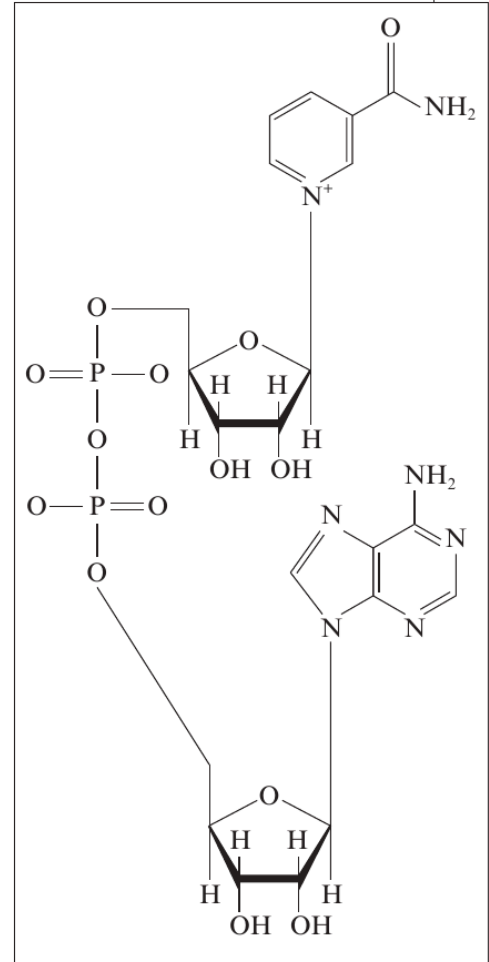
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6. The two diagrams below show nicotinamide adenine dinucleotide (NAD) and flavin adenine dinucleotide (FAD), two nucleotides used in respiration.



FAD



NAD

(a) State **two** chemical features which these two molecules have in common and **one** difference between the two molecules. [3]

Features in common.

(i)

(ii)

Difference

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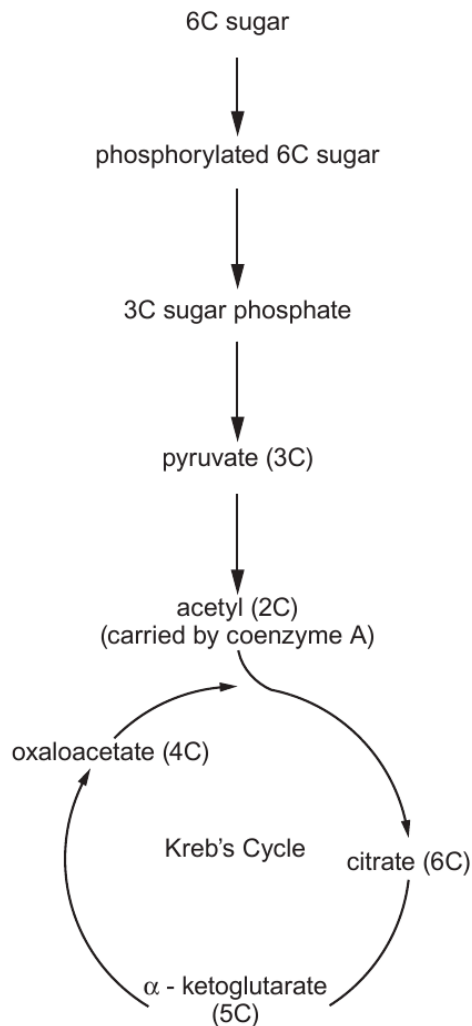
(b) Substrate level phosphorylation (SLP) is the simplest, oldest and least-evolved way to make ATP. In substrate level phosphorylation, ATP is made during the conversion of an organic molecule from one form to another. Energy released during the conversion is used to synthesise the high energy bond of ATP.

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(i) Describe the position of the 'high energy bond of ATP' referred to in the paragraph above. [1]

(ii) Suggest why SLP is referred to as the 'simplest and oldest way to make ATP'. [2]

The diagram below shows glycolysis, the link reaction and Krebs's cycle.



- (iii) Draw **two** arrows labelled **A** and **B** on the diagram opposite to show the **two** steps where there is conversion of an organic molecule from one form to another and SLP occurs. [2]
- (iv) Give the number of ATP molecules made by SLP at **each** of the conversions shown in part (iii) **per glucose molecule** in aerobic respiration. [2]

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Arrow	Number of ATP molecules made per glucose molecule in aerobic respiration.
A	
B	

- (c) (i) Where does the link reaction occur in cells? [1]

- (ii) Name the **two** types of enzyme involved in the link reaction. [1]
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END OF QUESTION PACK

5 questions · 68 marks · ~1 h 49 min

Source: WJEC BY4 + BY5 (2008 modular spec, 2011–2017)

Curated for WJEC Biology 2015 spec A2 Unit 3 – Topic 5 (3.3)

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