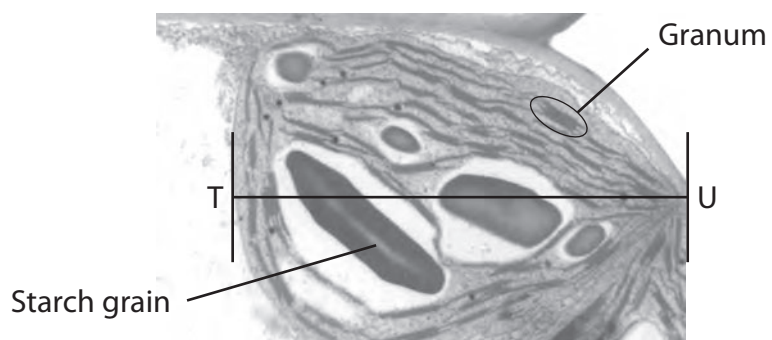


10 Photosynthesis is a process that occurs in all green plants.

The electron micrograph shows part of a chloroplast in a plant cell.



(a) (i) The labelled starch grain in the chloroplast is $2.2 \mu\text{m}$ long.

Calculate the width of this chloroplast between T and U.

(2)

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(ii) Explain the relationship between the structure and functions of a granum in photosynthesis.

(3)

Dotted lines for writing the answer to question (ii).

(b) Describe how starch is formed from the products of the light-independent reactions of photosynthesis.

(4)

Dotted lines for writing the answer to question (b).



P 5 2 2 8 8 A 0 3 1 3 6

*(c) Herbicides kill weeds by affecting their growth.

The effect of herbicides on the production of starch in the leaves of *Echinochloa crus-galli* (barnyard grass) has been investigated.

The table shows the results for four herbicides: Diuron, Propanil, Linuron and Swep.

Concentration of herbicide / $\mu\text{g cm}^{-3}$	Relative percentage of starch produced (%)			
	Diuron	Propanil	Linuron	Swep
0.0	100	100	100	100
0.1	0	50	50	100
1.0	0	0	0	50
10.0	0	0	0	0
100.0	0	0	0	0

It is thought that these herbicides act on the light-dependent reactions of photosynthesis.

Devise an investigation that would produce quantitative data on the effectiveness of the herbicides on the light-dependent reactions of photosynthesis.

(6)

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Handwriting practice area with 15 horizontal dotted lines.

(Total for Question 10 = 15 marks)

TOTAL FOR PAPER = 100 MARKS



P 5 2 2 8 8 A 0 3 3 3 6

4 Photosynthesis is a two-stage process by which plants fix carbon dioxide.

(a) Describe the light-dependent reactions of photosynthesis.

(5)

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(b) The products of the light-dependent reactions are used in the light-independent reactions.

(i) In which part of the chloroplast do the light-independent reactions take place? (1)

- A envelope
- B granum
- C stroma
- D thylakoid

(ii) What is the name of the enzyme used by plants to fix carbon dioxide? (1)

- A GALPase (glyceraldehyde-3-phosphatase)
- B GPase (glycerate-3-phosphatase)
- C RUBISCO (ribulose biphosphate carboxylase/oxygenase)
- D RuBPase (ribulose biphosphatase)

(iii) Which of the following is the immediate product of the light-independent reactions of photosynthesis? (1)

- A glucose
- B GP
- C RuBP
- D starch

(Total for Question 4 = 8 marks)



10 A student investigated the light-dependent reactions of photosynthesis in spinach leaves.

The leaves were cut into pieces and ground in a cold solution of sucrose and a buffer.

The mixture was filtered and centrifuged. The liquid in the tube was poured off and kept in an ice water bath.

The pellet at the bottom of the tube was suspended by mixing with fresh sucrose and buffer and stored in an ice water bath.

Four tubes were then set up as follows:

Tube	Liquid poured off after centrifuging / cm³	Resuspended pellet / cm³	Sucrose and buffer solution / cm³
1	–	0.5	–
2	–	–	0.5
3	–	0.5	–
4	0.5	–	–

The tubes had 5 cm³ of DCPIP added to them. Tube 3 was kept in the dark and the others kept in the light.

After twenty minutes, the colour in each tube was recorded. The results are shown in the table below.

Tube	Colour in tube
1	pale green
2	blue
3	blue
4	blue

(a) (i) Give **two** reasons why a cold solution containing sucrose and a buffer was used in this investigation.

(2)

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(ii) Give a reason why tube 3 was used in this investigation.

(1)

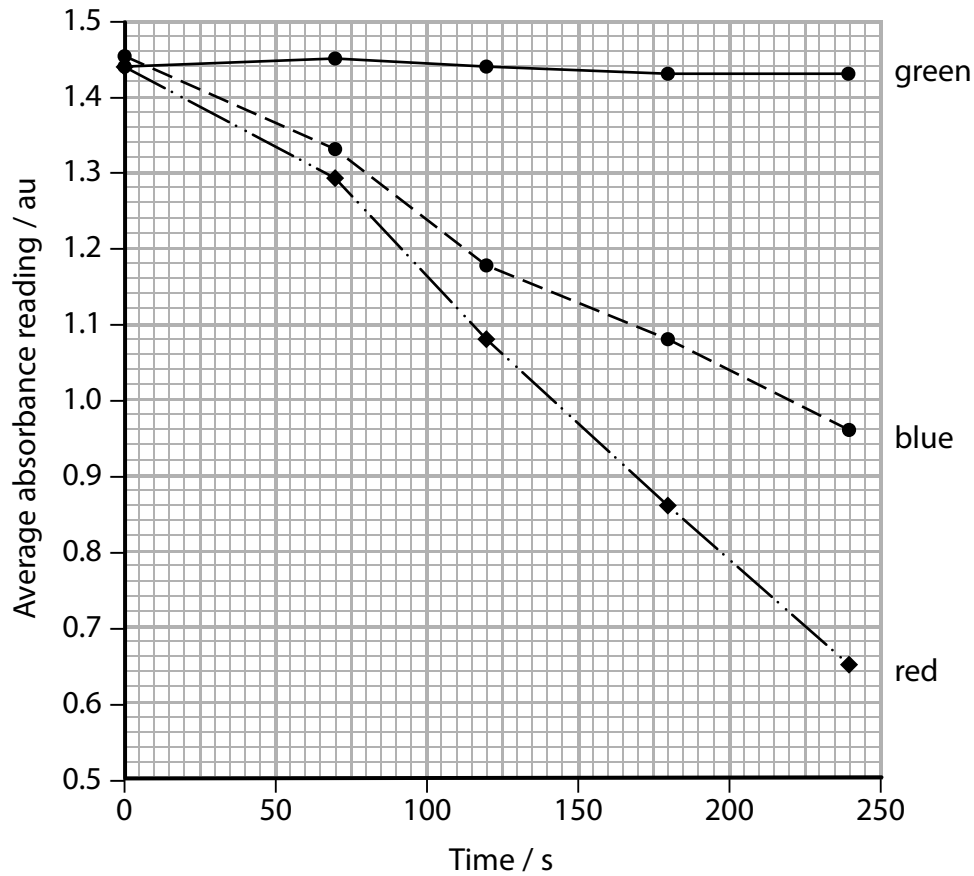
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(iii) In another investigation, the student wanted to determine the effect of different wavelengths of light on the light-dependent stage of photosynthesis.

The student modified her first investigation to obtain results.

The graph shows the results of her modified investigation.



Explain how the student modified the practical procedure of the first investigation to enable these results to be obtained.

(4)

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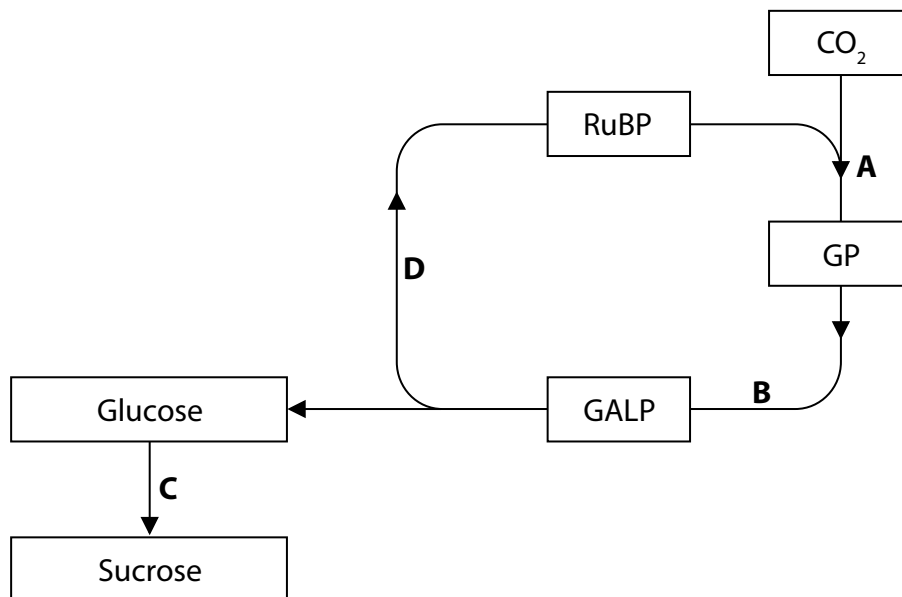
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(b) The diagram shows part of the Calvin cycle (light-independent reactions) of photosynthesis.



Place a cross in the box which indicates the correct stage (A – D) for the following statements.

(i) The stage which involves a condensation reaction and fructose.

(1)

- A
- B
- C
- D

(ii) The stage where the enzyme RUBISCO is involved.

(1)

- A
- B
- C
- D

(Total for Question 10 = 9 marks)

7 DNA is a polymer made from monomers called nucleotides.

(a) Describe how nucleotides join together to form DNA.

(2)

(b) Different theories for DNA replication have been suggested. Figure 1 illustrates two of these theories.

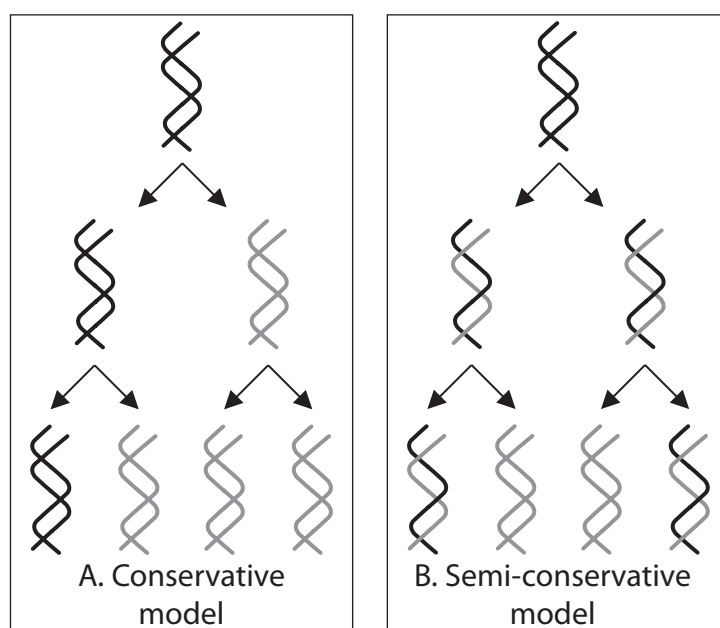


Figure 1

Meselson and Stahl carried out experiments to test these theories for DNA replication.

Figure 2 shows the results from one of their experiments.

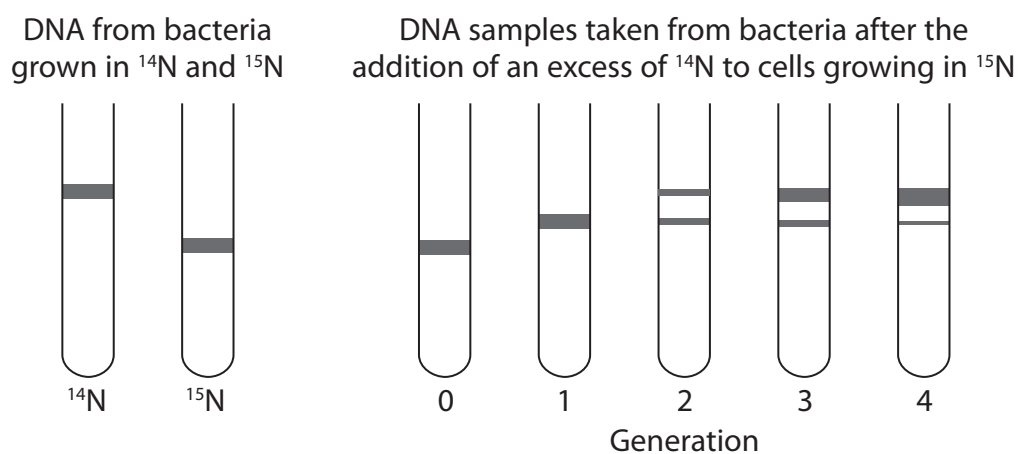


Figure 2



Analyse the data to explain why Meselson and Stahl accepted one of the models for DNA replication and rejected the other.

(4)

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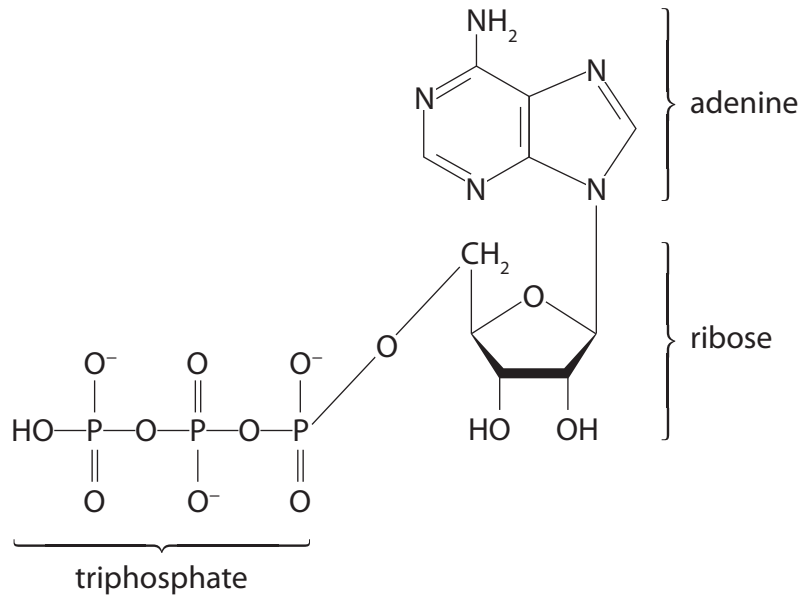
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P 4 9 8 5 3 A 0 2 5 3 2

(c) The diagram shows the structure of ATP.



Compare and contrast the structure of ATP and a DNA nucleotide.

(3)

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(Total for Question 7 = 9 marks)



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Question Number	Answer	Additional Guidance	Mark
10(a)(i)	<ul style="list-style-type: none"> • correct measurements from the photograph (1) • correct answer (1) 	<p><u>Example of calculation</u></p> <p>Starch grain 27mm and width of chloroplast 60mm</p> <p>$27000 \div 22 = 12\,273$</p> <p>$60000 \div 12\,273 = 4.889 \text{ (}\mu\text{m)}$</p> <p>ALLOW 4.9 / 4.89 / 4.8 recurring (μm)</p> <p>(ALLOW one mark for correct calculation from different measurements)</p>	(2)

Question Number	Answer	Additional Guidance	Mark
10(a)(ii)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> • (granum) is formed from many layers of thylakoid membranes to increase surface area (for absorbing light) (1) • thylakoid membranes contain chlorophyll to absorb light (1) • electron carrier molecules in thylakoid membrane involved in ATP production (1) 	<p>ALLOW stacks of thylakoids provide a large surface area</p> <p>ALLOW photosystems / photosynthetic pigments in place of chlorophyll</p> <p>ALLOW for light dependent reaction in place of absorb light</p> <p>ALLOW ATP synthase / photophosphorylation</p>	(3)

Question Number	Answer	Additional Guidance	Mark
10(b)	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> • two GALP used to produce a glucose molecule (1) • (glucose molecules are) joined together by glycosidic bonds to form starch (1) • by condensation reactions (1) • producing amylose and amylopectin (1) 	<p>ALLOW triose phosphate instead of GALP</p> <p>ALLOW maltose / polysaccharide</p>	(4)

Question Number	Indicative content
*10(c)	<p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p>Basic information</p> <ul style="list-style-type: none"> • Use of all 4 herbicides • Control of a variable e.g. temperature, pH or light intensity • Variable related to barnyard grass considered e.g. age of plant <p>Evidence of linkages</p> <ul style="list-style-type: none"> • Sensible herbicide concentration selected, either a range from 0 to 10 $\mu\text{g cm}^{-3}$ or 0.1 $\mu\text{g cm}^{-3}$ • Hill reaction / use of DCPIP to measure light dependent reactions • Isolate chloroplasts • Method for controlling abiotic variables <p>Evidence for sustained scientific reasoning</p> <ul style="list-style-type: none"> • Suitable control described e.g. tubes in the dark • Description of how the reaction would be quantified e.g. time taken to decolourise DCPIP / use of a colorimeter • Statistical analysis to compare effectiveness of herbicides on photosynthesis • Measure of effectiveness described e.g. the more effective the herbicide the longer the time taken to decolourise the DCPIP, the herbicide that had most effect on decolourisation of DCPIP at the lowest concentration

Level	Mark	Descriptor	
0	Marks	No awardable content	
Level 1	1-2	<p>An explanation of how the investigation should be modified may be attempted but with limited analysis, interpretation and/or evaluation of the scientific information. Generalised comments made.</p> <p>The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.</p>	<p>Description of use of herbicides Control of a variable e.g. temperature, pH or light intensity Variable related to barnyard grass considered e.g. age of plant</p>
Level 2	3-4	<p>An explanation of how the investigation should be modified will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information.</p> <p>The explanation shows some linkages and lines of scientific reasoning with some structure.</p>	<p>Sensible range of herbicide concentrations between 0 and 100 $\mu\text{g cm}^{-3}$ Hill reaction / use of DCPIP to measure light dependent reactions Isolate chloroplasts Method for controlling abiotic variables</p>
Level 3	5-6	<p>An explanation of how the investigation should be modified is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information.</p> <p>The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured.</p>	<p>Focus on range of herbicide concentrations between 0 and 1 $\mu\text{g cm}^{-3}$ Suitable control described e.g. tubes in the dark Description of how the reaction would be quantified e.g. time taken to decolourise DCPIP / use of a colorimeter</p> <p>Statistical analysis to compare effectiveness of herbicides on photosynthesis</p>

Question Number	Answer	Additional Guidance	Mark
4(a)	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> • use of light (energy) to excite electrons in chlorophyll (1) • {photolysis / splitting of water} to produce oxygen, electrons and hydrogen ions (1) • electrons used { in the electron transport chain / to replace those lost by chlorophyll } (1) • generation of ATP / photophosphorylation (1) • reduction of NADP (1) 	<p>ALLOW electrons promoted to higher energy level ALLOW photosystem (PS) I or II for chlorophyll</p> <p>ALLOW correct equation</p> <p>ALLOW electrons used in redox reactions / electrons move along electron carrier proteins</p>	5

Question Number	Answer	Mark
4(b)(i)	<p>4(b)(i). The only correct answer is C – Stroma</p> <p>A is not correct because light-independent reactions take place in the stroma</p> <p>B is not correct because light-independent reactions take place in the stroma</p> <p>D is not correct because light-independent reactions take place in the stroma</p>	1

Question Number	Answer	Mark
4(b)(ii)	<p>4(b)(ii). The only correct answer is C – RUBISCO (ribulose bisphosphate carboxylase/oxygenase)</p> <p>A is not correct because RUBISCO (ribulose bisphosphate carboxylase/oxygenase) is the enzyme that fixes carbon dioxide</p> <p>B is not correct because is not correct because RUBISCO (ribulose bisphosphate carboxylase/oxygenase) is the enzyme that fixes carbon dioxide</p> <p>D is not correct because is not correct because RUBISCO (ribulose bisphosphate carboxylase/oxygenase) is the enzyme that fixes carbon dioxide</p>	1

Question Number	Answer	Mark
4(b)(iii)	<p>4(b)(iii). The only correct answer is B – GP</p> <p>A is not correct because glucose is made from the products of the light-independent reactions</p> <p>C is not correct because RuBP is the molecule that CO₂ combines with to form molecules of GP</p> <p>D is not correct because starch is formed from glucose</p>	1

Question Number	Acceptable Answer	Additional guidance	Mark
10(a)(i)	An answer that makes reference to the following: <ul style="list-style-type: none"> • {cold / buffered} to stop enzyme denaturation (1) • sucrose to stop osmotic loss of water from chloroplasts (1) 		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
10(a)(ii)	<ul style="list-style-type: none"> • tube 3 is a control to show DCPIP does not change colour over time (1) 		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
10(a)(iii)	An explanation that makes reference to the following: <ul style="list-style-type: none"> • set up tubes identical to tube 1 so that chloroplasts are available (1) • set up several tubes to ensure data is reliable (1) • tubes exposed to light of different wavelengths for same time because time affects number of electrons released / tubes exposed to light of same intensity because intensity affects number of electrons released (1) • use a colorimeter with a red filter to measure absorbance (1) 		(4)

Question Number	Acceptable Answer	Additional guidance	Mark
10(b)(i)	C		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
10(b)(ii)	A		(1)

(Total for Question 10 = 9 marks)

Question Number	Answer	Additional Guidance	Mark
7 (a)	<p>A description which includes two of the following:</p> <ul style="list-style-type: none"> • condensation reaction (1) • phosphodiester bonds (1) • DNA polymerase (1) 	<p>Must be in context of forming a DNA strand</p> <p>ALLOW hydrogen bonding between bases (in context of double strand)</p> <p>ALLOW bonds forming between phosphate and deoxyribose</p>	(2)

Question Number	Answer	Additional Guidance	Mark
7 (b)	<p>An explanation which includes the following:</p> <ul style="list-style-type: none"> • The conservative model was rejected / the semi-conservative model was accepted (1) • (due to) generation 1 has a single band which is halfway between ^{15}N and ^{14}N (1) • (because) the DNA has one strand containing ^{15}N and one strand containing ^{14}N (1) • (in semi-conservative model) further generations would have {a band which is halfway between ^{15}N and ^{14}N / no band at ^{15}N} (1) 	<p>ALLOW light band for ^{14}N and heavy band for ^{15}N ALLOW nitrogen – 14 / nitrogen – 15 ALLOW the evidence {supports semi-conservative model / does not support conservative model} ALLOW medium density</p> <p>ALLOW DNA contains half heavy nitrogen and half light</p> <p>ALLOW (in conservative model) further generations would have { no band halfway between ^{15}N and ^{14}N / a band at ^{15}N }</p>	(4)

Question Number	Answer	Additional Guidance	Mark
7 (c)	<p>An answer that that makes reference to the following:</p> <p>Similarity</p> <ul style="list-style-type: none"> • both contain phosphate, pentose sugar and a base (1) <p>and two of the following</p> <p>Differences</p> <ul style="list-style-type: none"> • a DNA nucleotide contains deoxyribose whereas ATP contains ribose (1) • a DNA nucleotide could contain other bases whereas ATP contains only {adenine / one base type} (1) • a DNA nucleotide contains one phosphate whereas ATP {contains three phosphates / is a triphosphate} (1) 	<p>ACCEPT DNA could contain C, T or G whereas ATP only contains A</p>	<p>(3)</p>