Name	Date started	Target end date

GCE A LEVEL — BIOLOGY UNIT 3 QUESTION PACK

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

REVISE
.wales

BIOLOGY — UNIT 3 · PHOTOSYNTHESIS — CALVIN CYCLE, PIGMENTS & LIMITING FACTORS

3.2 Photosynthesis — the light-independent stage, photosynthetic pigments and limiting factors

The Calvin cycle (CO_2 fixation by RuBisCO, reduction of GP to triose phosphate using ATP and NADPH, regeneration of RuBP), the major photosynthetic pigments separated by chromatography, and how light intensity, CO_2 concentration and temperature can each limit the rate of photosynthesis.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~58 min

Derived from the legacy BY4 / BY5 papers' pace of ~1.3 min/mark, padded for long-prose answers (36 marks over 3 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 3 (3.2).

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.

For Examiner's use only

Q	Source	Max	Mark
1	BY4 Jun 11 Q2	10	
2	BY4 Jun 12 Q3	14	
3	BY4 Jun 15 Q4	12	
	Total	**36**	

Photosynthesis — Calvin Cycle, Pigments & Limiting Factors — what the new spec asks

WJEC GCE A Level Biology (from 2015) · Unit 3: Energy, Homeostasis & the Environment · Topic 3.2.

Calvin cycle — stages

- Fixation: CO_2 + RuBP → 2 GP, catalysed by RuBisCO.
- Reduction: GP + ATP + NADPH → triose phosphate (TP).
- Regeneration: 5 TP → 3 RuBP using ATP.

Products & uses of TP

- Two TP make one hexose sugar (glucose, fructose).
- Also forms amino acids, fatty acids, glycerol.
- Most TP is recycled to regenerate RuBP.

Photosynthetic pigments

- Chlorophyll a, chlorophyll b — primary pigments.
- Carotenoids (carotene, xanthophyll) — accessory pigments.
- Separated by paper / TLC chromatography; identified by R_f values.

Limiting factors

- Light intensity — saturates at high values.
- CO_2 concentration — usually the main limiter.
- Temperature — affects enzyme rate; optimum ~25 °C.

Crib sheet »

Photosynthesis — Calvin Cycle, Pigments & Limiting Factors in one page

Quick-reference notes — revisit before each question.

Calvin overview

Light-independent — in the stroma.

CO_2 fixed onto RuBP by RuBisCO.

Three phases: fixation, reduction, regeneration.

Fixation

RuBP (5C) + CO_2 → 6C unstable intermediate → 2 GP (3C).

RuBisCO is the most abundant enzyme on Earth.

Reduction

GP + ATP + NADPH → triose phosphate (TP).

ATP donates phosphate; NADPH donates electrons.

2 TP → 1 hexose; rest regenerates RuBP.

Regeneration

5 TP (15C total) → 3 RuBP (15C).

Uses 3 ATP.

Keeps the cycle going.

Chromatography

Paper / TLC — pigments separated by solubility.

R_f = distance pigment / distance solvent.

Identify pigment by characteristic R_f + colour.

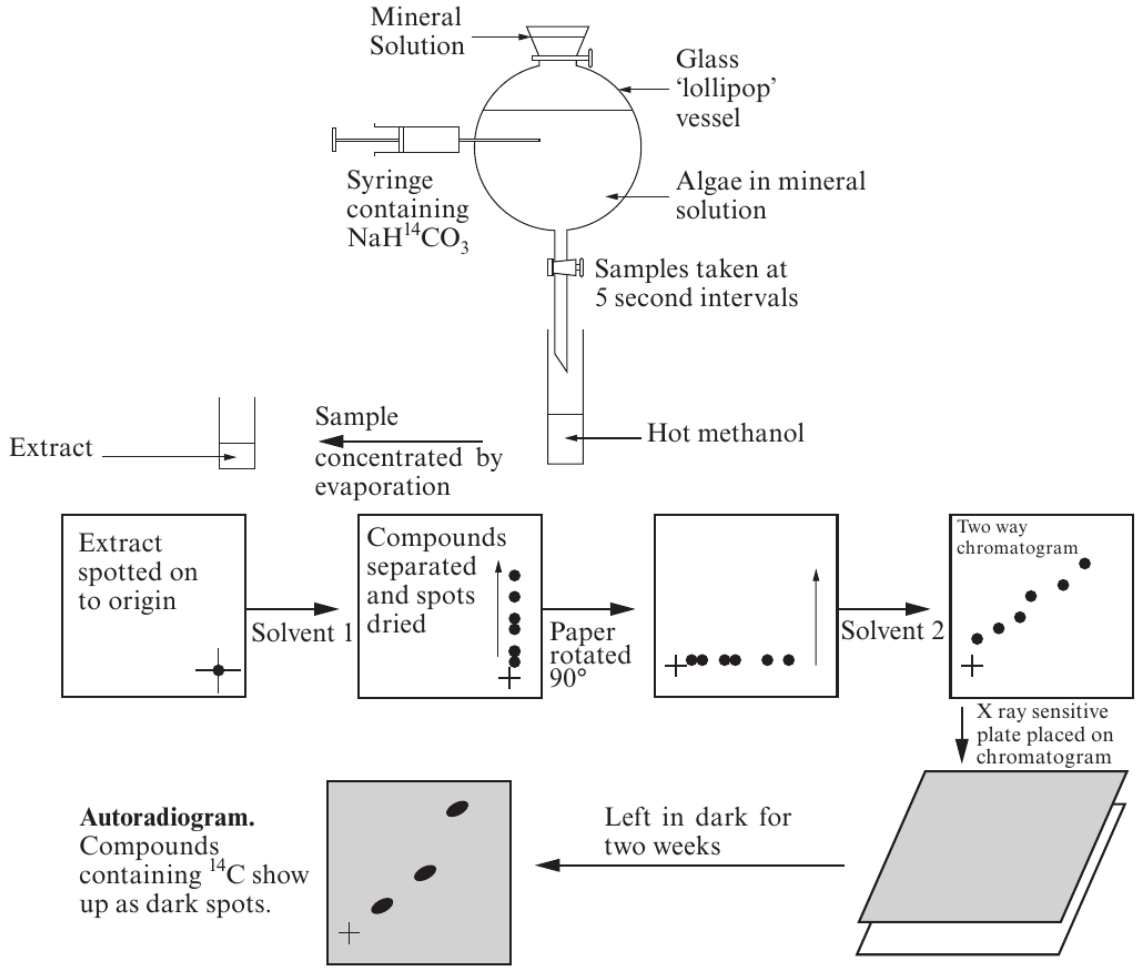
Limiting factors

Light, CO_2, temperature compete to limit rate.

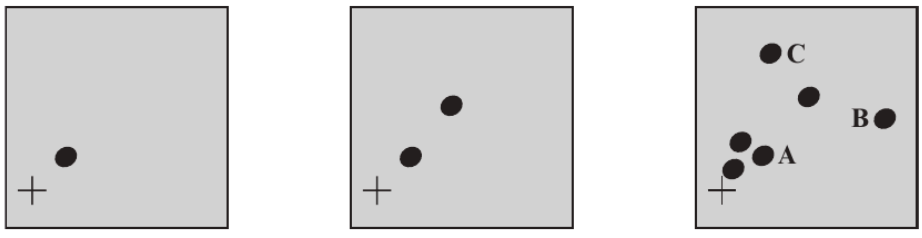
Increase the most limiting → rate rises until next factor kicks in.

Read graphs: rising portion = factor limiting.

2. Calvin did experiments on a series of reactions which is now called the light independent stage of photosynthesis. The diagram shows one such experiment. The apparatus was set up as shown and brightly illuminated. The clock was started on the introduction of radioactive hydrogen carbonate ions.



Autoradiograms from one such experiment are shown below:



After 5 seconds After 10 seconds After 30 seconds

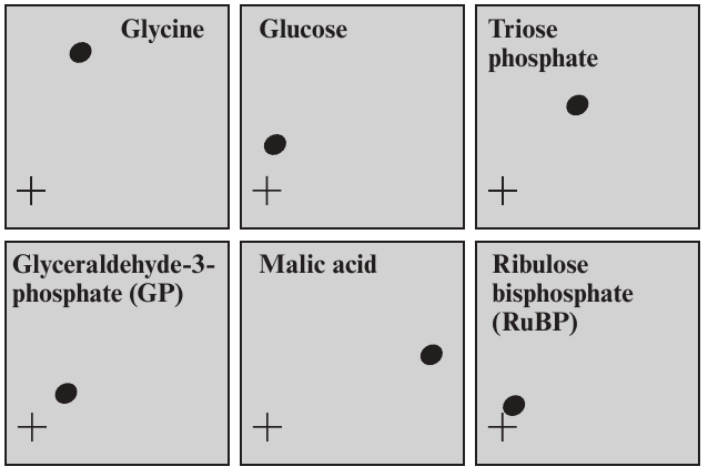
Examiner only

(a) What is the main difference between these three autoradiograms? [1]

.....

.....

(b) To identify the substances represented by the dark spots, Calvin made autoradiograms of known substances. He then compared their positions with those of the dark spots. The results of some of these are shown below.



Use these autoradiograms and the ones shown in part *(a)* to identify compounds represented by spots **A-C**. [1]

Spot	Name of compound
A	
B	
C	

(c) Use the autoradiograms to determine which were the first and second substances formed. [2]

First .....

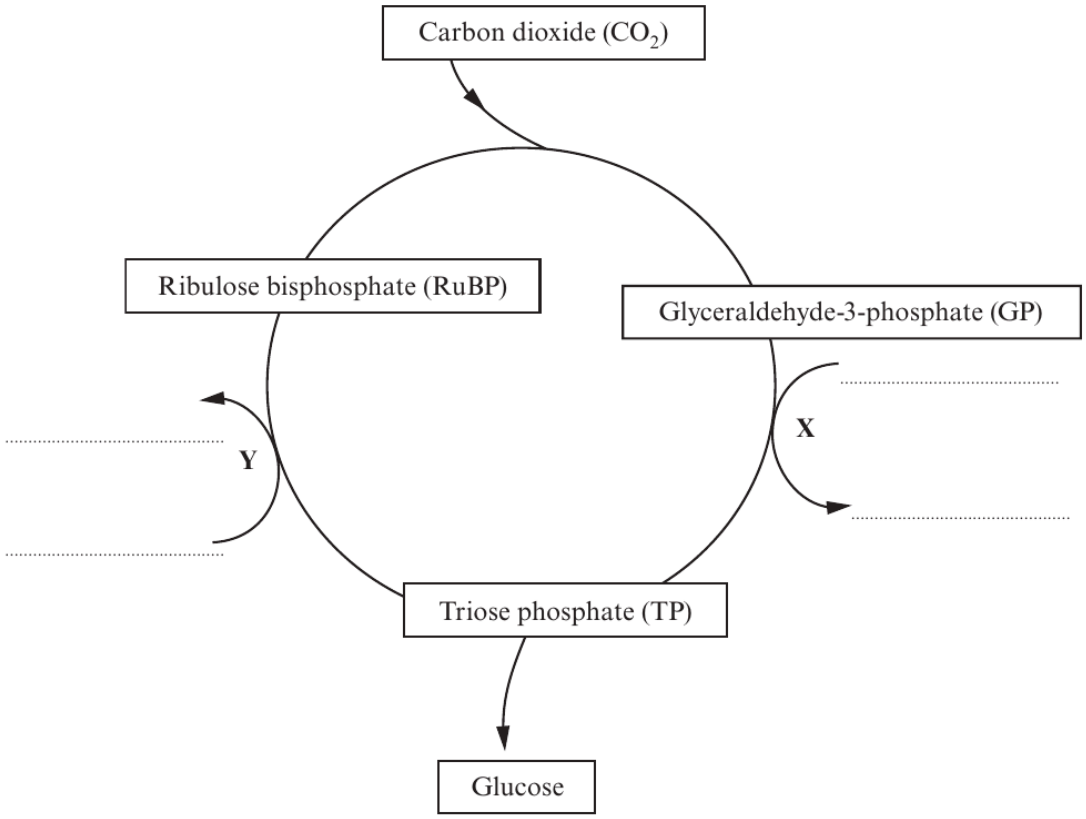
Second .....

(d) Glycine is an amino acid. Which chemical element would have been needed in the mineral solution in order for the algae to have made this compound? [1]

.....

Examiner only

(e) Calvin worked out that the ribulose bisphosphate is regenerated so that the reactions are in the form of a cycle, which is summarised below:



Compound **X** is a hydrogen carrier and compound **Y** is the universal energy currency in cells.

(i) Complete the diagram to show how compounds **X** and **Y** change during the cycle. [2]

(ii) Which series of reactions provides the compounds **X** and **Y** in chloroplasts? [1]

.....

(iii) State precisely where the production of **X** occurs in chloroplasts. [1]

.....

(f) How many molecules of triose phosphate would be needed to synthesise three molecules of glucose? [1]

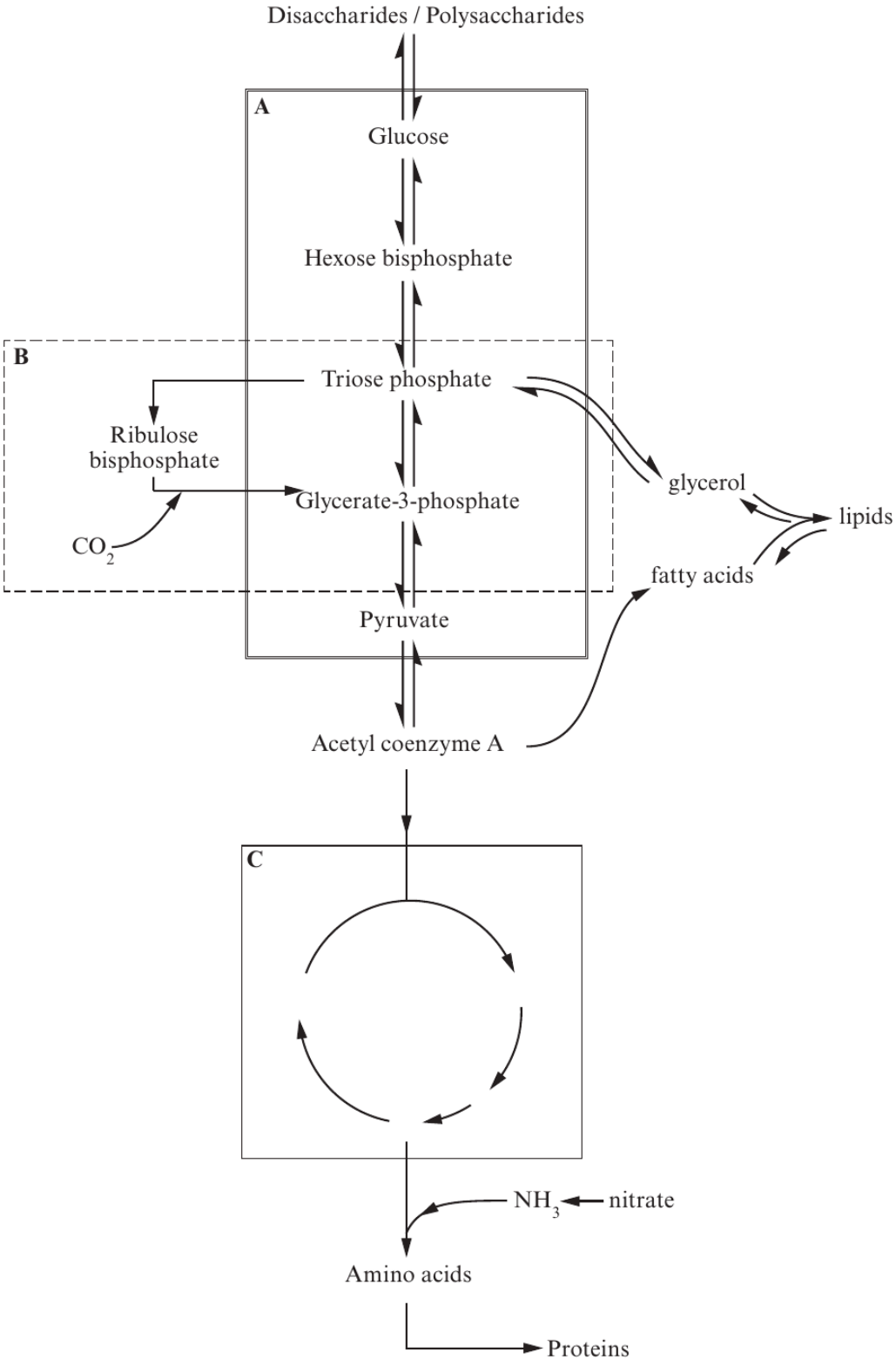
.....

(Total 10 marks)

BLANK PAGE

Examiner only

3. Some of the metabolic pathways which take place in plant cells are shown in the following diagram.



Examiner only

(a) (i) State the names of the processes in the boxes labelled **A**, **B** and **C**. [3]

A .....

B .....

C .....

(ii) Explain how it is possible for the three metabolic pathways (**A**, **B** and **C**) to take place independently of each other in the same cell. [3]

.....

.....

.....

.....

.....

.....

(iii) A series of reactions which are essential for process **B** to continue are not shown. Complete the following sentences describing this series of reactions: [4]

A series of reactions which are light ..... take place in the ..... of the chloroplasts. These reactions produce ..... and ..... which are needed for process **B** to continue.

(b) Explain why photosynthesis is essential for the survival of animals on this planet. [2]

.....

.....

.....

.....

(c) (i) Plant cells also need nitrate ions to synthesise amino acids State **one** *other* use of nitrates in plants. [1]

.....

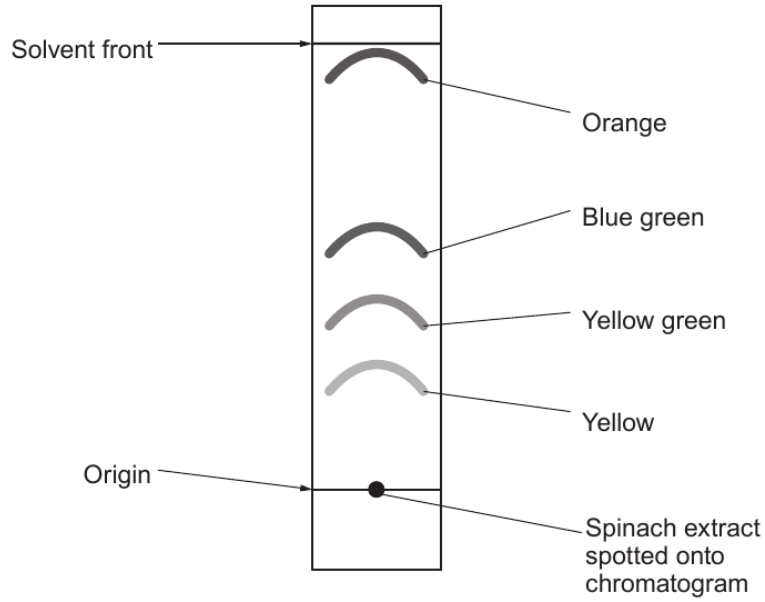
(ii) Why is magnesium required by plant cells? [1]

.....

(Total 14 marks)

Examiner only

4. A student carried out a practical to separate the pigments in spinach leaves and the results are shown in the diagram below.



(a) The blue-green pigment is chlorophyll *a*.
State precisely where chlorophyll *a* is found in a photosynthetic cell. [2]

.....

Examiner only

(b) The Rf value of the pigments can be calculated using the following formula.

$$\textbf{Rf} = \frac{\text{distance moved by pigment from origin}}{\text{distance moved by solvent front from origin}}$$

Calculate the Rf value of the yellow band and use the following table of Rf values to identify it. Show your working. [3]

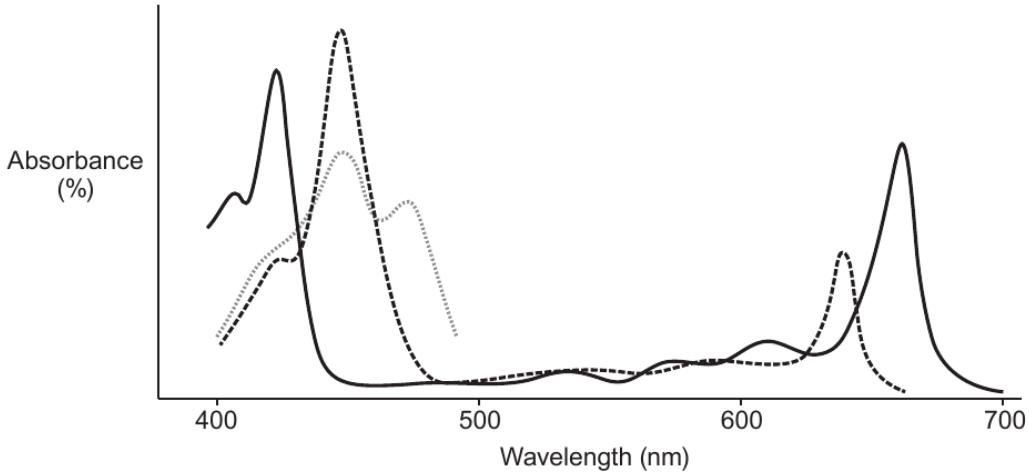
Rf value = ...

Pigment	Rf value
xanthophyll	0.28
chlorophyll *b*	0.42
chlorophyll *a*	0.59
carotene	0.98

Identity of yellow band .....

Examiner only

(c) Some of the pigments were extracted from the chromatogram separately. The percentage of light absorbed at wavelengths from 400 to 700 nm by each of them was measured and a chart produced.



(i) Name this type of chart. [1]

.....

(ii) Explain the results in the 500 to 600 nm range. [1]

.....

.....

.....

(iii) Explain the advantage to plants of having more than one pigment in their leaves. [2]

.....

.....

.....

.....

.....

.....

Examiner only

(d) Use your knowledge of photosynthesis to explain the role of these pigments in the production of ATP. [3]

12

END OF QUESTION PACK

3 questions · 36 marks · ~58 min
Source: WJEC BY4 + BY5 (2008 modular spec, 2011–2017)
Curated for WJEC Biology 2015 spec A2 Unit 3 — Topic 3 (3.2)