IB Biology C1.3 Photosynthesis - Worksheet 2

Photosynthetic pigments and chromatography | SL core | Total: 43 marks | Suggested time: 55 min

Name: _____ **Class:** _____ **Date:** _____

Assessment instructions: Answer all sections. Show calculations and units where relevant. HL questions are marked [HL]. The answer key and marking guidance are included at the end for teacher review or self-assessment.
Learning focus: chlorophyll and accessory pigments; paper chromatography; Rf values; colour and light absorption

Section A - Multiple choice (5 marks)

1. The Rf value of a pigment is calculated by (1)
   A. distance moved by solvent / distance moved by pigment.
   B. distance moved by pigment / distance moved by solvent.
   C. mass of pigment / mass of solvent.
   D. time taken by pigment / time taken by solvent.

2. In paper chromatography, the paper is the (1)
   A. mobile phase.
   B. stationary phase.
   C. solvent front.
   D. reaction centre.

3. A pigment with a high Rf value in a given solvent has usually (1)
   A. moved a shorter distance than the solvent.
   B. a lower solubility in the mobile phase.
   C. moved relatively far with the solvent.
   D. remained at the origin.

4. Leaves appear green because many photosynthetic pigments (1)
   A. absorb green light very strongly.
   B. reflect/transmit green wavelengths more than red or blue.
   C. contain no pigments except carotene.
   D. absorb all visible wavelengths equally.

5. Carotenoids are useful in photosynthesis mainly because they (1)
   A. split water directly.
   B. broaden the range of wavelengths absorbed.
   C. replace ATP synthase.
   D. fix carbon dioxide in the Calvin cycle.

Section B - Short answer

6. Explain why a leaf can contain yellow/orange pigments even when it appears green. (3)

7. Describe how paper chromatography separates photosynthetic pigments. (4)

8. State two reasons why a calculated Rf value might differ from a published Rf value. (2)

9. Suggest why different plant species may have different pigment profiles. (3)

Section C - Data response / case study

A student separated pigments from a leaf extract. The solvent front moved 10.0 cm from the origin. Published values for this solvent are: carotene 0.95, xanthophyll 0.71, chlorophyll a 0.65, chlorophyll b 0.45.

Band	Colour	Distance from origin / cm
1	orange	9.4
2	yellow	7.0
3	blue-green	6.4
4	yellow-green	4.6

10a. Calculate the Rf value for each band. Show one example calculation. (4)

10b. Use colour and Rf value to identify each band. (4)

10c. Identify the pigment that was most soluble in the solvent and justify your answer. (2)

10d. Explain why pigments that are not obvious in the original leaf become visible on the chromatogram. (2)

10e. Give one improvement that would increase confidence in the pigment identification. (2)

Section D - Extended response

11. Design a chromatography investigation to compare pigments in two plant leaves. Include variables, method, safety and how the data would be processed. (8)

Answer key and marking guidance

Award credit for equivalent wording. Marks should be awarded for valid biological reasoning, correct use of data, and clear links to photosynthesis. Do not require exact phrasing unless a term is specified.

Section A - Multiple choice

Question	Answer	Guidance
1	B	Rf = distance moved by pigment / distance moved by solvent.
2	B	Paper is the stationary phase.
3	C	A high Rf means the substance traveled far relative to solvent front.
4	B	Green wavelengths are reflected or transmitted, so they are seen.
5	B	Accessory pigments absorb additional wavelengths.

Section B - Short answer

6. Up to 3 marks: leaves contain several pigments; chlorophyll green colour is usually more intense/abundant and masks carotenoids; separation makes pigments visible as separate bands.

7. Up to 4 marks: pigment mixture placed at origin; solvent/mobile phase moves by capillary action; pigments dissolve to different extents and bind to paper differently; different migration rates produce separate bands.

8. Any two: different solvent; different paper/stationary phase; measurement error; overloaded sample; pigment degradation; temperature/humidity; solvent front not marked immediately.

9. Up to 3 marks: species differ genetically; pigments are adapted to light conditions/habitat; different accessory pigments broaden absorption; leaf age/season/stress can alter pigment concentrations.

Section C - Data response / case study

10a. Band 1: 9.4/10.0 = 0.94; band 2: 7.0/10.0 = 0.70; band 3: 6.4/10.0 = 0.64; band 4: 4.6/10.0 = 0.46. Award 1 mark per correct Rf value to two decimal places.

10b. Band 1 carotene; band 2 xanthophyll; band 3 chlorophyll a; band 4 chlorophyll b. Award 1 mark each, using both Rf and colour.

10c. Carotene/band 1. It moved the furthest and has the highest Rf, showing greatest solubility in the mobile phase and/or lowest affinity for the paper.

10d. Pigments are separated from masking pigments; each band concentrates a particular pigment so colours can be distinguished.

10e. Any one with explanation: run repeats; include pure pigment standards; measure distances precisely from origin to band centre; keep solvent below origin; use same solvent and paper as reference values.

Section D - Extended response

11. Mark out of 8. Award up to 2 for clear method: grind leaves with solvent, spot origin, develop in covered chamber, mark solvent front. Up to 2 for variables: independent variable leaf species; dependent variables pigment colours/Rf values; controlled variables solvent, paper, extraction mass, run time, temperature, distance. Up to 2 for data processing: calculate Rf values, compare with standards, repeats/mean. Up to 1 for safety: eye protection, flammable/irritant solvent handling. Up to 1 for validity/reliability: replicate chromatograms or use standards.