InkBiology

ANSWER BOOK

Limiting factors and primary productivity

Photosynthesis and primary productivity · Unit B13

AQA 3.5.1, 3.5.3 · OCR A 5.2.1, 6.3.1 · Edexcel A Topic 5.6 · CAIE 13.2, 18.1

6 questions · 21 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 **B1** a limiting factor is the factor, of all those a process requires, whose shortage is holding the rate back at that moment, and the only one whose increase would speed the process up. **B1** productivity is measured in kJ m^{-2} $year^{-1}$, that is energy per unit area per unit time. [2]

SECTION B · Standard, 3 to 5 marks

B1 **B1** on the steep part at low light intensity the rate rises as light intensity rises, so light is the limiting factor there. **B1** the three curves coincide in that region, which shows the extra carbon dioxide is doing nothing, because there is not enough light energy to use what is already present. **B1** where a curve levels off, more light no longer raises the rate, so light has stopped being limiting and something else has taken over. **B1** the curves plateau at different heights, and since carbon dioxide concentration is what differs between them, carbon dioxide is the factor limiting the rate at the plateau; a plateau marks the point where the factor on the horizontal axis stopped mattering, not an absolute maximum. [4]

B2 **M1** net primary productivity = gross primary productivity minus the energy lost in respiration by the producers. **A1** 18 000 - 6 000 = 12 000 kJ m^{-2} $year^{-1}$, with both parts of the unit kept. **M1** percentage transfer = energy in the consumers ÷ net primary productivity × 100 = 1 080 ÷ 12 000 × 100. **A1** 9.0 per cent; dividing by the gross figure would be wrong, because the energy the producers had already respired away was never available to a herbivore. [4]

B3 **B1** not all of the material in the level below is eaten: roots, wood and dead litter are left behind. **B1** not all of what is eaten is digested, and the indigestible part leaves the body as faeces. **B1** some of what is absorbed is lost in excretion, as urea in mammals. **B1** a large share of the rest is respired to power movement and, in birds and mammals, to maintain a constant body temperature, so only what is left builds new tissue; transfer to a bird or mammal is often only 5 to 10 per cent, while transfer to an insect or a fish can be higher. [4]

B4 **B1** enrichment raises the rate only while carbon dioxide is genuinely the limiting factor. **B1** through a dull December week the light intensity is low, so light is limiting and the extra carbon dioxide cannot be used: there is not enough energy to drive the light-dependent stage and supply the Calvin cycle. **B1** the rate is set by whichever factor is in shortest supply, so raising any other factor changes nothing and the cost of the gas is spent for no return. **B1** the enrichment should be dosed on a light sensor, so gas is released only when the light is bright enough for carbon dioxide to become limiting, and supplementary lamps are the change that would help on the dull days. [4]

B5 **B1** every living plant cell respires continuously, day and night, while photosynthesis happens only in the light, so what is measured from outside is the difference between the two rates. **B1** at the compensation point the rate of photosynthesis exactly equals the rate of respiration, so there is no net exchange of carbon dioxide or of oxygen and no organic matter accumulates. **B1** a shade plant reaches its compensation point at a low light intensity, so under a closed canopy it still spends much of the day above it and gains, whereas a sun plant needs far more light to break even and would spend the day running at a loss on its stores. [3]