# Past-paper walk-through

## Bioaccumulation and Biomagnification ▪ 8.8

eXercise

# Questions in this set

- 2024 Set 1 Q1
- 2022 Set 1 Q1
- 2021 Set 1 Q2

# Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

# Question 1

2024 Set 1 ▪ Q1

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**Dissolved Oxygen and Biological Oxygen Demand in a Stream Ecosystem**

[Diagram: a cross-section of a stream divided into five vertical zones (A through E) labeled left to right, with “Direction of Streamflow” arrow pointing right along the bottom axis. The y-axis (unlabeled numerically) ranges from “Low” at the bottom to “High” at the top, showing two curves: a solid line for “Dissolved oxygen” and a

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dashed line for "Biological oxygen demand". Common fish/macroinvertebrate species listed above each zone:

- Zone A: adult fish; mayfly, stone fly, and caddis fly larvae
- Zone B: blackfly and midge larvae
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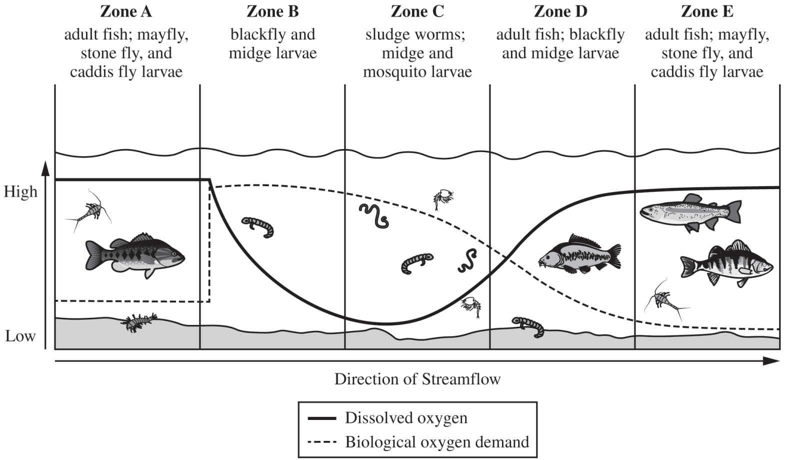
Curve behavior: In Zone A, dissolved oxygen is High (solid line flat at top) and biological oxygen demand is Low (dashed line flat at bottom). Moving into Zone B, dissolved oxygen (solid line) drops sharply from High to Low while biological oxygen demand (dashed line) rises sharply from Low to High. In Zone C, dissolved oxygen remains Low (solid line near bottom) while biological oxygen demand remains High (dashed line near top), with the two curves close together at their extremes. Moving into Zone D, dissolved oxygen (solid line) rises back up from Low to High while biological oxygen demand (dashed line) falls back down from High to Low. In Zone E, dissolved oxygen is High (solid line flat at top) again and biological oxygen demand is Low (dashed line flat at bottom), mirroring Zone A.]

**(a)** Based on the information in the diagram, **identify** the zone with the lowest level of dissolved oxygen.

# Question 1



Zone A
adult fish; mayfly, stone fly, and caddis fly larvae
Zone B
blackfly and midge larvae
Zone C
sludge worms; midge and mosquito larvae
Zone D
adult fish; blackfly and midge larvae
Zone E
adult fish; mayfly, stone fly, and caddis fly larvae
High
Low
Direction of Streamflow
Dissolved oxygen
Biological oxygen demand

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**(b)** Based on the information in the diagram, **describe** the relationship between biological oxygen demand and dissolved oxygen.

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**(c)** Based on the information in the diagram, **identify** the zone where there is most likely point-source water pollution discharged into the stream.

The research team is interested in investigating the relationship between dissolved oxygen levels and macroinvertebrate species richness in the stream. Researchers counted the number of macroinvertebrate species in zones A, B, and C during the summer months. The researchers selected zone A to serve as the control in the investigation.

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**(d) Identify** the dependent variable in the researchers' investigation.

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**(e) Identify** a testable hypothesis for the researchers' investigation.

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**(f) Describe** the reason the researchers selected zone A to serve as the control in the investigation.

The researchers decided to repeat their data collection during the winter months.

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**(g) Explain** how the modification to collect data in the winter months could alter the results of the investigation.

Stream ecosystems are affected by point-source organic pollution in a variety of ways.

# Question 1

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**(h) Describe** the effect that the introduction of raw sewage into the stream could have on the population of bacteria in the stream.

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**(i) Identify** an abiotic factor other than dissolved oxygen and organic pollution that could also influence the population size of bacteria in the stream.

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**(j) Explain** how persistent organic pollutants can affect higher trophic levels in an aquatic food web.

# Solution 1

## (a)

**Mark scheme**

- Zone C has the lowest level of dissolved oxygen (based on the diagram).

# Solution 1

**(b)**

**Mark scheme**

- Biological oxygen demand (BOD) and dissolved oxygen (DO) are inversely related: as BOD increases, DO decreases (equivalently, as DO increases, BOD decreases).

# Solution 1

**(c)**

**Mark scheme**

- Zone B is where point-source water pollution is most likely discharged into the stream (based on the diagram).

# Solution 1

**(d)**

**Mark scheme**

- The dependent variable is the number of macroinvertebrate species (macroinvertebrate diversity / macroinvertebrate species richness) — the researchers measured this in response to dissolved oxygen level.

# Solution 1

## (e)

**Mark scheme**

- A testable hypothesis relates dissolved oxygen level to macroinvertebrate species number, e.g.: 'As dissolved oxygen levels increase, the number of macroinvertebrate species increases' (or the inverse: as DO decreases, species number increases; or a general statement of a direct/inverse relationship between DO and macroinvertebrate species number). A null hypothesis of no relationship is also acceptable.

# Solution 1

## (f)

**Mark scheme**

- Zone A was chosen as the control because it is upstream from the pollution/organic waste source, so it is not affected by (not impacted by) the discharge — its dissolved oxygen levels reflect conditions unaffected by the pollution, giving a baseline for comparison.

# Solution 1

**(g)**

**Mark scheme**

- Collecting data in winter could alter the results because: (1) cold water holds more dissolved oxygen, which could increase the number of species; or (2) colder temperatures may fall below the tolerance range of some organisms, decreasing the number of species; or (3) lower light levels in winter reduce plant photosynthesis, which lowers dissolved oxygen and could decrease the number of species.

# Solution 1

**(h)**

**Mark scheme**

- Raw sewage introduces nutrients (and/or organic matter) that increase the bacteria population (more food source), and/or raw sewage directly contains bacteria that increases the bacteria population size in the stream.

# Solution 1

**(i)**

**Mark scheme**

- Any abiotic factor other than dissolved oxygen and organic pollution that affects bacteria population size, e.g.: temperature, pH, light/sunlight, turbidity/sediment, salinity, or nitrate/phosphate concentration.

# Solution 1

## (j)

**Mark scheme**

- Persistent organic pollutants (POPs) bioaccumulate/biomagnify in the tissues of organisms at higher trophic levels because those organisms consume prey that have already accumulated the pollutants, so pollutant concentration increases up the food web (often concentrating in fatty tissue); this can cause effects such as neurological toxicity in top predators.

# Question 1

2022 Set 1 ▪ Q1

Common snapping turtles, *Chelydra serpentina*, are primarily aquatic, but they lay their eggs on land. Researchers are interested in understanding the impact of pollution on turtle nesting sites. The researchers examined nesting sites at two agricultural areas along the floodplain of a river upstream and downstream from a chemical factory that is a known source of aqueous mercury pollution. Turtle eggs, soil, and vegetation samples taken from areas around turtle nests downstream from the chemical factory showed high levels of mercury in a previous study. Mercury was not detected in samples taken upstream from the chemical factory.
[Diagram: "DISTRIBUTION OF TURTLE NESTS ALONG RIVER." A map shows a river winding from top to bottom with an arrow labeled "Direction of Flow" pointing downstream. A "Chemical Factory" sits beside the river partway down, with a "Discharge Pipe" emptying into the river at that point. Along the riverbank are

# Question 1

forested strips labeled "Forest Area" (trees drawn as small pine-tree and round-tree icons). "Area A" is a region upstream of the chemical factory's discharge point (bounded by dashed lines), shown with many nest markers clustered together: a mix of filled circles (•) labeled "Successful turtle nest" and X marks (×) labeled "Unsuccessful turtle nest" in the legend — Area A shows a dense cluster of both successful (•) and unsuccessful (×) nests close together in the forest area. "Area B" is a region downstream of the chemical factory's discharge point (bounded by dashed lines), shown with a sparser, more scattered mix of successful (•) and unsuccessful (×) nest markers, with unsuccessful (×) nests appearing more numerous/closer to the river relative to successful (•) nests, which sit farther back. Legend box: "• Successful turtle nest" and "× Unsuccessful turtle nest."]

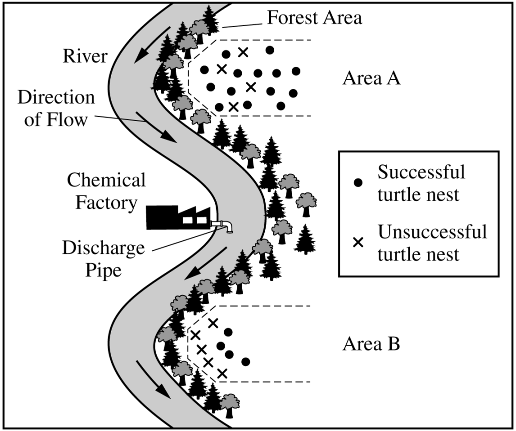
**(a)(i) Identify** the area with the greatest nest success rate, based on the information in the diagram.

# Question 1

**(a)(ii) Identify** the dependent variable in the study.
**(a)(iii)** Based on the information provided, **identify** a likely scientific question for the study.
**(a)(iv) Describe** why researchers measured mercury levels in locations upstream from the factory.
**(a)(v)** There are plans to remove trees and other vegetation along the river bank. **Explain** how this modification could affect the location and number of successful turtle nests in Area B.

# Question 1

DISTRIBUTION OF TURTLE NESTS ALONG RIVER



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2022 Set 1 ▪ Q1

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factory's discharge point (bounded by dashed lines), shown with many nest markers clustered together: a mix of filled circles (•) labeled "Successful turtle nest" and X marks (×) labeled "Unsuccessful turtle nest" in the legend — Area A shows a dense cluster of both successful (•) and unsuccessful (×) nests close together in the forest area. "Area B" is a region downstream of the chemical factory's discharge point (bounded by dashed lines), shown with a sparser, more scattered mix of successful (•) and unsuccessful (×) nest markers, with unsuccessful (×) nests appearing more numerous/closer to the river relative to successful (•) nests, which sit farther back. Legend box: "• Successful turtle nest" and "× Unsuccessful turtle nest."]

**(b)(i)** Mercury can affect organisms and ecosystems in many ways. **Describe** how a persistent pollutant, such as mercury, can negatively affect an organism.

**(b)(ii)** **Describe** how a persistent pollutant, such as mercury, can negatively affect an ecosystem.

# Question 1

**(b)(iii)** Researchers measured methylmercury in a location downstream from the factory. **Explain** how methylmercury could be present in the stream.

**(b)(iv)** Researchers claimed that the soil nearest to the river has higher levels of mercury than the field has, and those elevated levels have affected the nesting success for turtles. **Explain** how the pattern shown in the diagram supports or refutes this claim.

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**(c)** The turtle study was conducted in an agricultural area. **Describe** how a specific agricultural practice changes the soil in an area.

# Solution 1

## (a)(i)

### Mark scheme

- Area A (the site/area upstream from the factory) has the greatest nest success rate.

## (a)(ii)

### Mark scheme

- The dependent variable is turtle nesting success.

# Solution 1

## (a)(iii)

**Mark scheme**

- A likely scientific question: Does mercury content in the turtle's habitat affect common snapping turtle nest success? (Alternatively: Does mercury content in the turtle's habitat affect the location/site of common snapping turtle nests?)

# Solution 1

## (a)(iv)

### Mark scheme

- The upstream locations acted as a control group in the study, used to compare against the high-mercury turtle nests found downstream.

# Solution 1

## (a)(v) Mark scheme

- Removing riverbank vegetation could affect nesting as follows (any one): with more open area closer to the river, turtles don't have to travel as far to nest, so they are exposed to higher mercury levels near the river, decreasing the number of successful nests; with less vegetation to take up/remove mercury (heavy metals/endocrine disruptors/pesticides), concentrations in the soil increase, decreasing successful nests; soil erosion along the stream increases, making nest-building harder and decreasing successful nests; or with less vegetation/shade, soil temperature increases and moisture decreases, decreasing successful nests.

# Solution 1

## (b)(i)

**Mark scheme**

- A persistent pollutant like mercury can harm an organism because it bioaccumulates in tissues (it does not break down easily and accumulates over time); mercury is a neurotoxin that disrupts the nervous system/neuron functioning; or it disrupts normal functioning of the brain/kidneys/liver/immune system/reproductive system and can lead to death.

# Solution 1

## (b)(ii)

**Mark scheme**

- A persistent pollutant can harm an ecosystem because it biomagnifies up the food chain, giving top predators very high concentrations (which can cause a trophic cascade if predators die off); or because decreased reproductive success in exposed organisms alters food webs/trophic structure and reduces biodiversity/ecosystem stability.

# Solution 1

## (b)(iii)

**Mark scheme**

- Mercury is likely released into the stream by the factory as a waste product; bacteria/microorganisms in the water and sediments then convert the inorganic mercury into methylmercury.

# Solution 1

## (b)(iv)

### Mark scheme

- The diagram supports the claim: nests close to the river in Area B, where mercury levels are high, are not successful, while nests farther from the river are successful — supporting the claim that elevated soil mercury reduces nesting success. (Alternatively: Area B, closer to the river, has fewer total/successful nests than Area A, further supporting the claim.)

# Solution 1

## (c) Mark scheme

- Any one specific agricultural practice and its soil effect: tilling/plowing loosens/softens soil and/or removes organic matter, leading to erosion; monocropping removes nutrients and/or moisture; synthetic fertilizer use disrupts soil chemistry; irrigation can cause waterlogging, erosion, and/or salinization; slash-and-burn removes vegetation and upper organic soil layers (though it can add nutrients); heavy machinery use compacts soil; polyculture/cover cropping with nitrogen-fixing plants adds soil nutrients; or manure/organic fertilizer use increases soil moisture content.

# Question 2

2021 Set 1 ▪ Q2

Pesticides have been utilized for many years to increase food production and control pest populations. Pesticide use can be both beneficial and harmful to humans and other organisms.

**(a)** Pesticide use has advantages, disadvantages, and unintended consequences on human health. **Describe** one benefit to human health that can result from the use of pesticides.

# Question 2

2021 Set 1 ▪ Q2

Pesticides have been utilized for many years to increase food production and control pest populations. Pesticide use can be both beneficial and harmful to humans and other organisms.

**(b) Identify** one way chemical pesticides can enter the human body.

# Question 2

2021 Set 1 ▪ Q2

Pesticides have been utilized for many years to increase food production and control pest populations. Pesticide use can be both beneficial and harmful to humans and other organisms.

**(c)(i)** Cotton farmers in the southern United States used a chemical pesticide to control an insect cotton-crop pest over a 40-year period. To study the effectiveness of the pesticide as an insect pest-control strategy, traps were placed in treated cotton fields and the number of pests captured were compared to application rates for the pesticide. The results of the study are shown in the table below.

| Year | Grams of Pesticide Applied per Hectare | Number of Crop Insect Pests Captured |
|---|---|---|
| 1960 | 0 | 700 |
| 1975 | 500 | 2 |
| 1980 | 500 | 3 |
| 1985 | 500 | 8 |
| 1990 | 550 | 14 |
| 1995 | 600 | 83 |
| 2000 | 700 | 150 |
| 2005 | 800 | 405 |
| 2010 | 900 | 727 |
| 2015 | 1,000 | 1,100 |

# Question 2

Use the data in the table to answer the following questions.

**Identify** the year when the pesticide was most effective at reducing the size of the pest population.

**(c)(ii) Describe** the change in the number of crop insect pests in the cotton fields over time.

**(c)(iii) Explain** how the change in the cotton-crop pesticide effectiveness between the initial application in 1975 and the latest application in 2015 illustrates genetic resistance in pests, based on the data in the table.

# Question 2

2021 Set 1 ▪ Q2

Pesticides have been utilized for many years to increase food production and control pest populations. Pesticide use can be both beneficial and harmful to humans and other organisms.

**(d) Describe** TWO effects of pesticide use, other than death, on nontarget wildlife.

# Question 2

2021 Set 1 ▪ Q2

Pesticides have been utilized for many years to increase food production and control pest populations. Pesticide use can be both beneficial and harmful to humans and other organisms.

**(e)(i)** There are many problems associated with the repeated application of chemical pesticides to reduce pest populations.

Crop rotation is often used to reduce pesticide use. **Describe** the process of crop rotation.

**(e)(ii) Propose** one reasonable method, other than crop rotation, of reducing the use of pesticides in agricultural practices while still maintaining a high crop yield.

**(e)(iii) Justify** how the method proposed in (e)(ii) would provide a benefit to humans.

# Solution 2

## (a)

**Mark scheme**

- One benefit to human health from pesticide use (accept one): pesticides control disease vectors such as mosquitoes, ticks, rats, and mice that spread disease to/between humans; they reduce exposure to stinging insects that carry disease; or they increase food production, which decreases famine / increases food availability and thereby improves human health.

# Solution 2

**(b)**

**Mark scheme**

- One way chemical pesticides can enter the human body (accept one): inhalation/breathing in aerosols and powders (e.g. during application on farms, yards, golf courses); drinking water contaminated by pesticide runoff; consumption of food carrying pesticide residue; or dermal absorption through the skin during application of the pesticide.

# Solution 2

## (c)(i)

**Mark scheme**

- Identify the year the pesticide was most effective at reducing the pest population size: 1975 (the year of the initial application, when the number of crop insect pests captured was lowest).

# Solution 2

## (c)(ii)

**Mark scheme**

- Describe the change in the number of crop insect pests in the cotton fields over time: the pest population was high before the pesticide was first used, then dropped dramatically right after the initial 1975 application, and then increased again over subsequent years even as more pesticide (grams per hectare) was applied — overall, captures rose from about 2 pests in 1975 to about 1,100 pests by 2015 (roughly 700 to 1,100 across the full 1960–2015 span).

# Solution 2

## (c)(iii)

**Mark scheme**

- Explain how the change between the 1975 and 2015 applications illustrates genetic resistance: over time the same (or an increasing) amount of pesticide kills a smaller fraction of the pest population, because pests with a genetic resistance to the pesticide survive each application and reproduce, passing that resistance to their offspring. This is the "pesticide treadmill" — each year more pesticide must be applied, yet the number of pests captured (surviving) steadily increases, showing that an increasing share of the population carries genetic resistance to the pesticide.

# Solution 2

## (d) Mark scheme

- Describe TWO effects of pesticide use (other than death) on nontarget wildlife (accept any two): the pesticide may contaminate soil/water, negatively affecting organisms; it may bioaccumulate in an organism's body; it may biomagnify up the food web/chain; nontarget organism populations may increase where competitors/predators are removed and new habitat opens up; predator species may decrease, letting prey species grow rapidly; endocrine disruption may cause reproductive or developmental abnormalities; pesticides can disrupt signaling/communication in bees; they can cause eggshell thinning or other developmental abnormalities; or they can eliminate a food supply and disrupt the food chain for other species.

# Solution 2

## (e)(i)

**Mark scheme**

- Describe the process of crop rotation: growing different crops in succession (in different seasons or years) on the same piece of land, rather than growing the same crop repeatedly — i.e. harvesting one crop and then planting a different crop in that same area.

# Solution 2

## (e)(ii)

**Mark scheme**

- Propose one method, other than crop rotation, to reduce pesticide use while still maintaining a high crop yield (accept one): integrated pest management combining biological, physical, and chemical controls; reducing stubble/crop residue in fallow fields that harbor pests; applying pesticide only when the pest is most susceptible; intercropping instead of monoculture to reduce pest habitat; or using pest-resistant genetically modified crops.

# Solution 2

## (e)(iii)

**Mark scheme**

- Justify how the method proposed in (e)(ii) benefits humans (accept one): it reduces pesticide residue in food and pesticide ingested by humans; it provides economic benefits such as less money spent on pesticides, increased farmer profit from crops, and less equipment/labor needed to spray fields; or it reduces the number of agricultural workers exposed to pesticides, improving their health.