1.2 Systems, feedback and models

Name: _____ Class: _____ Date: _____ **Total: 18 marks**

KEY WORDS storage • flow • transformation • negative feedback • positive feedback • tipping point • albedo

Objective

Build the skills to answer exam questions on **systems** : storages and flows, open and closed systems, **feedback** , **tipping points** and the strengths and limits of **models** .

You must be able to:

- draw and read systems diagrams with storages and flows
- tell transfers from transformations, and open, closed and isolated systems apart
- explain negative and positive feedback, equilibrium and tipping points
- evaluate the use of models

1 Key knowledge and worked examples

Systems

A **system** is a set of parts that work together. In a **systems diagram**, boxes are **storages** (stocks) and arrows are **flows**; the width of an arrow can show the size of the flow.

flow	what changes	example
transfer	the place only	water flowing down a river
transformation	the form, state or energy	water evaporating; light energy to chemical energy in photosynthesis

system	exchanges energy?	exchanges matter?	example
open	yes	yes	a forest, a lake
closed	yes	no (almost)	Earth as a whole
isolated	no	no	none in nature (the universe, in theory)

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Feedback: a change in the output returns to affect the input.

- **Negative** feedback **reduces** the change, so the system stays near a **steady-state equilibrium**: more prey → more predators → fewer prey.
- **Positive** feedback **increases** the change and moves the system away from equilibrium: warming → less ice → less sunlight reflected (**albedo** falls) → more warming.

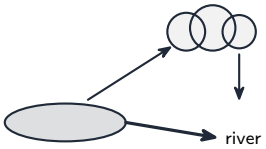
A **tipping point** is a critical threshold: past it, positive feedback drives the system to a new state that is hard to reverse, e.g. coral reefs to algae, or rainforest to savanna.

A **model** simplifies reality. Strengths: easier to understand, can predict, can test "what if". Limits: leaves things out, depends on its assumptions and data, so predictions are uncertain.

Answer shapes: for feedback, write the loop as a chain of arrows and say whether it ends by **reducing** or **increasing** the first change.

2 Practice

2.1 Distinguish between a transfer and a transformation, with **one** example of each from the water cycle. [2]



2.2 Classify each as an open, closed or isolated system, with a reason: (i) a pond; (ii) planet Earth; (iii) a sealed jar of pond water with plants, kept in the light. [3]



2.3 For each loop, state whether it is negative or positive feedback, and explain. (i) A deer population grows, so food runs short. (ii) Permafrost thaws and releases methane, which warms the climate further. [3]



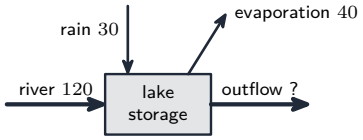
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3 Exam-style questions

3.1 The diagram shows a simple lake system.

(a) Identify **one** transformation in the diagram. [1]

(b) The inflows are 120 and 30 units a day; evaporation is 40 units a day. The lake level is steady. Calculate the river outflow. [2]



(c) State what would happen to the storage if the outflow fell to 80 units a day. [1]

3.2 Arctic sea ice reflects most of the sunlight that reaches it; open sea absorbs most of it.

(a) Explain how the loss of sea ice is an example of positive feedback. [3]



(b) Explain what is meant by a tipping point, using the sea ice as an example. [2]

(c) State **one** limitation of a climate model used to predict when the Arctic will be ice-free in summer. [1]

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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

transfer: matter moves place without changing form, e.g. runoff or a river flow; transformation: matter or energy changes form or state, e.g. evaporation or condensation

2.2

(i) open: energy and matter (water, animals, nutrients) enter and leave; (ii) closed: energy enters and leaves, but almost no matter; (iii) closed: light enters and heat leaves, but no matter

2.3

(i) negative: less food raises deaths and lowers births, so the population falls back; (ii) positive: methane is a greenhouse gas, so warming causes more thawing and more warming

3.1

(a) evaporation (liquid to gas)

(b) inputs = outputs at steady state: $120 + 30 = 40 + x$; $x = \mathbf{110}$ units a day

(c) inputs exceed outputs by 30 units a day, so the lake storage rises

3.2

(a) warming melts sea ice, exposing darker water; albedo falls, so more solar energy is absorbed; the water warms and more ice melts, so the change grows

(b) a threshold beyond which the system changes to a new state; e.g. once summer ice is lost, warm open water may stop it re-forming, and the change is hard to reverse

(c) any one: simplifies processes such as clouds or ocean currents; depends on future emissions, which are unknown; limited past data

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