Solutions

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

2.1

- population, community, ecosystem, biome

2.2

- energy **flows** one way - it enters as light or chemical energy, passes up the trophic levels and leaves as heat, so it must be continuously resupplied; matter **cycles** - the same atoms move between abiotic and biotic reservoirs and are reused indefinitely; which is why each cycle demonstrates the conservation of matter while energy is not conserved in a usable form

2.3

(a)

- the atmosphere

(b)

- rock

(c)

- the oceans

2.4

(a)

- nitrogen fixation

(b)

- nitrification

(c)

- denitrification

(d)

- ammonification

2.5

- phosphorus has **no gaseous phase** and no atmospheric reservoir, so it is released only by the slow weathering of rock rather than by rapid exchange with the air as carbon is

2.6

(a)

- autotroph - a chemical energy source

(b)

- heterotroph, decomposer

(c)

- heterotroph, scavenger

(d)

- autotroph

2.7

- any three of: to organise (build and maintain structure), to grow, to reproduce, to maintain homeostasis

2.8

- $8000 \times 0.1 = 800$ kJ to primary consumers; $800 \times 0.1 = 80$ kJ to secondary consumers

2.9

- decomposers break down dead organic matter, releasing the elements locked in it back into abiotic reservoirs where producers can take them up again - without this step matter would stay in dead tissue and the cycle would stop

3.1 B

- $-$ about 10%

3.2 B

- The atmosphere, not the soil, is the largest reservoir; plants cannot use atmospheric N_2 directly; denitrification converts nitrate to N_2, not to ammonium

3.3 B

- Conservation of matter is about atoms, not energy; and reservoirs certainly do change in size

3.4 B

- The added phosphate changes the phosphorus cycle, and the consequence spreads to oxygen, the carbon cycle and every trophic level

3.5

(a)

- rock; weathering released phosphate into soil and groundwater, and the fertiliser concentrated it before it ran off into the lake

(b)

- energy reaching each level is only a small fraction of the level below. The top predator sits at the highest level, so it depends on the largest number of transfers and receives the least energy, and it also has the smallest population and slowest reproduction. When oxygen loss killed the small fish, its energy supply was cut entirely, while the algae still had light and abundant phosphate and continued to grow

(c)

- the claim is **largely correct**. The phosphorus is not lost: it moves from the water into algal biomass, then into dead organic matter and lake sediment - all still reservoirs within the lake, so the matter is conserved and can re-enter the cycle. The energy genuinely is lost: it entered as sunlight, passed through the algae and was released as heat by respiration and decomposition, and heat cannot be recaptured by the ecosystem. The one qualification is that some phosphorus does leave, in fish that die downstream or are removed, and some matter is buried in sediment for long periods - so "not lost" means "not destroyed", not "still available"

(d)

- **Nitrogen**: decomposition of the dead algae greatly increases ammonification, so ammonium rises; as oxygen falls, nitrification (which needs oxygen) slows while denitrification (which does not) increases, so nitrogen is returned to the atmosphere faster. **Carbon**: photosynthesis by the algal bloom initially removes CO_2 rapidly, then decomposition and respiration by the decomposers release large amounts of CO_2 and consume the oxygen, which is the direct cause of the fish deaths

(e)

- Benefit: removing the dead algae removes the phosphorus and nitrogen stored in it from the lake entirely, so decomposition stops consuming oxygen and the bloom cannot be refuelled by released nutrients. Drawback: it also removes matter the lake's own cycles depend on, and it takes away the decomposers' energy source, so recovery of the normal food web may be slower - and it treats the symptom while the upstream run-off continues