Year 13 Science: Ocean composition, layers and circulation

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. Find the total pressure 500 m down. Use $\rho = 1025$ kg m^{-3}, $g = 9.8$ N kg^{-1} and air pressure 1.01×10^5 Pa.

2. In the Southern Hemisphere a wind blows from the south, towards the north. Which way is the net Ekman transport?

3. What happens to the salinity and density of surface water in the subtropics, where evaporation is strong?

4. Why does sea ice forming make the water beneath it denser?

5. Why is the thermocline near New Zealand stronger in summer than in winter?

Exam-style question: West Coast upwelling

Fishers on the West Coast notice that in some summers, when south-westerly winds blow for days, the sea near the shore turns cold and green and fish gather. When north-easterly winds blow, the sea stays warm and clear.

6. Describe how wind sets a surface current moving.

7. Explain how the south-westerly wind and the Coriolis effect cause upwelling along this coast.

8. Explain why upwelling makes the sea green and attracts fish.

9. Explain why north-easterly winds stop the upwelling.

Fix the mistake

10. Correct this statement: "The Coriolis effect makes currents turn right in New Zealand."

11. Correct this statement: "Ekman transport goes the same way as the wind."

12. Correct this statement: "Seawater is densest at 4 °C, so the deep ocean is at 4 °C."

13. Correct this statement: "The thermocline is the warm layer at the top."

Answer key (for parents and tutors)

1. Find the total pressure 500 m down. Use $\rho = 1025$ kg m^{-3}, $g = 9.8$ N kg^{-1} and air pressure 1.01×10^5 Pa.
   $\rho gh = 1025 \times 9.8 \times 500 = 5.02 \times 10^6$ Pa; total $= 5.02 \times 10^6 + 0.101 \times 10^6 = 5.12 \times 10^6$ Pa.
2. In the Southern Hemisphere a wind blows from the south, towards the north. Which way is the net Ekman transport?
   90° to the left of a northward wind: towards the west.
3. What happens to the salinity and density of surface water in the subtropics, where evaporation is strong?
   Both rise: evaporation removes water and leaves the salt behind.
4. Why does sea ice forming make the water beneath it denser?
   Ice holds little salt, so brine is rejected into the water below, making it saltier as well as near freezing.
5. Why is the thermocline near New Zealand stronger in summer than in winter?
   In summer stronger sunshine warms a thin surface layer and lighter winds mix less, so the temperature drop below it is sharp; in winter cooling and storms mix the surface deeper and the drop is gentler.
6. Describe how wind sets a surface current moving.
   Friction between the wind and the sea surface drags the top layer along; it drags the layer below, so motion passes downwards, weakening with depth (Achieved).
7. Explain how the south-westerly wind and the Coriolis effect cause upwelling along this coast.
   The wind blows north-east along the coast. In the Southern Hemisphere the Coriolis effect deflects moving water to the left, so each layer turns further left (the Ekman spiral) and the net transport is 90° to the left of the wind: north-west, offshore. Surface water moves away from the coast and cold water from below the pycnocline rises to replace it (Merit for linking wind, Coriolis and transport).
8. Explain why upwelling makes the sea green and attracts fish.
   The deep water is rich in nitrate and phosphate from decomposing matter that sank from above. Brought into the sunlit layer, these nutrients let phytoplankton photosynthesise and multiply, turning the water green; zooplankton and then fish feed on them (Merit).
9. Explain why north-easterly winds stop the upwelling.
   A north-easterly blows south-west along the coast, so Ekman transport is to its left: south-east, onshore. Surface water piles up against the coast and sinks (downwelling), the warm low-nutrient layer thickens, and the pycnocline blocks nutrients, so productivity falls (Excellence links wind direction, Coriolis, transport and nutrients for both seasons).
10. Correct this statement: "The Coriolis effect makes currents turn right in New Zealand."
    In the Southern Hemisphere moving water and air are deflected to the left.
11. Correct this statement: "Ekman transport goes the same way as the wind."
    Net Ekman transport is at right angles to the wind, to the left in the Southern Hemisphere.
12. Correct this statement: "Seawater is densest at 4 °C, so the deep ocean is at 4 °C."
    That is fresh water; normal seawater gets denser right down to about −1.9 °C, and deep water is about 0 to 4 °C.
13. Correct this statement: "The thermocline is the warm layer at the top."
    The thermocline is the transition layer where temperature falls quickly with depth, between the mixed layer and the deep layer.