Year 13 Science: Atmospheric circulation: cells, wind belts and the westerlies

Name: _____ Date: _____

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

Practice

1. Find the Coriolis parameter f at 30° S.

2. Which wind belt is New Zealand in, and which direction does it blow from?

3. Which way does air circulate around a low in the Southern Hemisphere?

4. Air at 20 °C at sea level crosses a 1500 m range, with cloud forming from 500 m. Using 9.8 °C per km dry and 6.0 °C per km in cloud, find its temperature back at sea level on the other side.

5. Why are winds light in the doldrums?

Exam-style question: deserts and trade winds

Central Australia, at about 25° to 30° S, is one of the driest places on Earth, while northern Australia has a wet season of heavy tropical rain.

6. Describe where air rises and sinks in the Hadley cell.

7. Explain why the region near 30° S is so dry.

8. Explain why the surface trade winds in the Southern Hemisphere blow from the south-east.

9. Explain why northern New Zealand often has long settled spells in summer.

Fix the mistake

10. Correct this statement: "The westerlies blow towards the west."

11. Correct this statement: "In New Zealand air goes clockwise around a high."

12. Correct this statement: "Air sinks at 30° because it has reached the edge of the cell."

13. Correct this statement: "The nor'wester is hot because it comes from Australia."

Answer key (for parents and tutors)

1. Find the Coriolis parameter f at 30° S.
   $f = 2 \times 7.29 \times 10^{-5} \times \sin 30° = 2 \times 7.29 \times 10^{-5} \times 0.5 = 7.29 \times 10^{-5}\ s^{-1}$.
2. Which wind belt is New Zealand in, and which direction does it blow from?
   The westerlies, blowing from the west (north-west to south-west).
3. Which way does air circulate around a low in the Southern Hemisphere?
   Clockwise.
4. Air at 20 °C at sea level crosses a 1500 m range, with cloud forming from 500 m. Using 9.8 °C per km dry and 6.0 °C per km in cloud, find its temperature back at sea level on the other side.
   Up to 500 m: 20 − 9.8 × 0.5 = 15.1 °C; 500 to 1500 m in cloud: 15.1 − 6.0 = 9.1 °C; down 1500 m dry: 9.1 + 9.8 × 1.5 = 23.8 °C.
5. Why are winds light in the doldrums?
   The air there is mostly rising, not moving sideways, and the Coriolis effect is almost zero, so there is little horizontal wind.
6. Describe where air rises and sinks in the Hadley cell.
   Air rises at the equator (the ITCZ), flows polewards high up, and sinks at about 30° (Achieved).
7. Explain why the region near 30° S is so dry.
   The air that sinks at 30° has already lost its moisture as rain in the tropics; as it sinks it is compressed and warms, so its relative humidity falls, clouds evaporate and rain cannot form, giving the high-pressure subtropical desert belt (Merit).
8. Explain why the surface trade winds in the Southern Hemisphere blow from the south-east.
   At the surface, air flows from the subtropical high at 30° S back towards the equatorial low, so it starts moving north. The Coriolis effect deflects it to the left in the Southern Hemisphere, turning it towards the north-west, so it blows from the south-east (Merit).
9. Explain why northern New Zealand often has long settled spells in summer.
   In the southern summer the Sun is further south, so the whole circulation, including the subtropical high-pressure belt, shifts south. Large slow-moving anticyclones then often sit over northern New Zealand; their sinking air suppresses cloud and they block the westerly fronts, giving long dry, settled spells (Excellence links heating, cell structure, seasonal shift and the weather).
10. Correct this statement: "The westerlies blow towards the west."
    Winds are named from where they come: westerlies blow from the west towards the east.
11. Correct this statement: "In New Zealand air goes clockwise around a high."
    In the Southern Hemisphere air goes anticlockwise around a high and clockwise around a low.
12. Correct this statement: "Air sinks at 30° because it has reached the edge of the cell."
    It sinks because it has cooled aloft and the Coriolis effect has turned it so it piles up and converges.
13. Correct this statement: "The nor'wester is hot because it comes from Australia."
    It is warm because it dropped its moisture on the West Coast and was compressed and warmed as it descended.