# Chapter 9: Atmospheric Circulation and Weather Systems

## Exercises — Exercises

Q1 Multiple choice question (i): If the surface air pressure is 1,000 mb, the air pressure at 1 km above the surface will be: (a) 700 mb (b) 1,100 mb (c) 900 mb (d) 1,300 mb

(c) 900 mb. In the lower atmosphere pressure falls by about 1 mb for every 10 m of height, so over 1 km (1,000 m) it drops by about 100 mb, from 1,000 mb to roughly 900 mb. Pressure never rises with height, which rules out 1,100 and 1,300 mb.

Q2 Multiple choice question (ii): The Inter Tropical Convergence Zone normally occurs: (a) near the Equator (b) near the Tropic of Cancer (c) near the Tropic of Capricorn (d) near the Arctic Circle

(a) near the Equator. Intense insolation there causes convection and a low pressure zone (equatorial low), where the trade winds from both hemispheres converge and rise. This convergence zone is the ITCZ.

Q3 Multiple choice question (iii): The direction of wind around a low pressure in northern hemisphere is: (a) clockwise (b) perpendicular to isobars (c) anti-clock wise (d) parallel to isobars

(c) anti-clockwise. Around a low (cyclonic circulation) winds blow anticlockwise in the northern hemisphere and clockwise in the southern hemisphere, as the Coriolis force deflects them to the right in the north.

Q4 Multiple choice question (iv): Which one of the following is the source region for the formation of air masses? (a) the Equatorial forest (b) the Himalayas (c) the Siberian Plain (d) the Deccan Plateau

(c) the Siberian Plain. Air masses form over large homogeneous surfaces such as vast oceans or plains, where air stays long enough to take on the area's temperature and humidity. The snow-covered Siberian plain is a source of continental polar air masses; forests, mountains and plateaus are not homogeneous.

Q5 Answer in about 30 words: (i) What is the unit used in measuring pressure? Why is the pressure measured at station level reduced to the sea level in preparation of weather maps?

Atmospheric pressure is measured in millibars (mb). Pressure falls with altitude, so station readings are reduced to sea level to remove the effect of height. Only then can pressure differences, which drive winds, be compared on weather maps.

Q6 Answer in about 30 words: (ii) While the pressure gradient force is from north to south, i.e. from the subtropical high pressure to the equator in the northern hemisphere, why are the winds north easterlies in the tropics?

The Coriolis force deflects moving air to the right in the northern hemisphere. Winds starting from the subtropical high and heading south toward the equator are therefore turned toward the west, blowing from the north-east as north-easterlies.

Q7 Answer in about 30 words: (iii) What are the geotrophic winds?

Geostrophic winds blow in the upper atmosphere, free of surface friction. When isobars are straight, the pressure gradient force is balanced by the Coriolis force, so the wind blows parallel to the isobars rather than across them.

Q8 Answer in about 30 words: (iv) Explain the land and sea breezes.

By day land heats faster than sea, so pressure is lower over land and a sea breeze blows from sea to land. At night land cools faster, pressure is lower over the sea, and a land breeze blows from land to sea.

Q9 Answer in about 150 words: (i) Discuss the factors affecting the speed and direction of wind.

Winds are set in motion by differences in air pressure, and horizontal winds near the surface respond to three forces. The pressure gradient force acts from high to low pressure at right angles to the isobars. It is strong where isobars are close together and weak where they are far apart, so closer isobars mean faster wind. The frictional force affects speed. It is greatest at the surface, extends up to about 1-3 km, and is minimal over the sea. The Coriolis force, caused by the earth's rotation, affects direction. It deflects wind to the right in the northern hemisphere and to the left in the southern, acts perpendicular to the pressure gradient force, increases with wind speed and latitude, is maximum at the poles and absent at the equator. Above 2-3 km, where friction is absent, the pressure gradient force and Coriolis force balance and the geostrophic wind blows parallel to the isobars. Gravity acts downward.

Q10 Answer in about 150 words: (ii) Draw a simplified diagram to show the general circulation of the atmosphere over the globe. What are the possible reasons for the formation of subtropical high pressure over 30° N and S latitudes?

The diagram (see Figure 9.6 of the chapter) shows three cells in each hemisphere: the Hadley cell (tropics), the Ferrel cell (mid-latitudes) and the polar cell. Surface winds are the easterlies in the tropics, westerlies in the middle latitudes and polar easterlies near the poles. Air rises at the ITCZ and at about 60° and sinks at about 30° and at the poles. Subtropical highs form at 30° N and S for two reasons. First, air heated and raised by convection at the equator reaches the top of the troposphere, about 14 km, and moves towards the poles, so air accumulates around 30° N and S. Second, this air cools as it reaches these latitudes. Part of the accumulated, cooled air sinks to the ground, building high pressure there. From this high, air flows back toward the equator as easterlies, completing the Hadley cell.

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Q11 Answer in about 150 words: (iii) Why does tropical cyclone originate over the seas? In which part of the tropical cyclone do torrential rains and high velocity winds blow and why?

Tropical cyclones need a large sea surface with temperature above 27 °C, the presence of the Coriolis force, small variation in vertical wind speed, a pre-existing weak low-pressure area or low-level cyclonic circulation, and upper divergence above the system. Warm tropical oceans meet these conditions. Their energy comes from condensation in the towering cumulonimbus clouds around the centre, and the sea gives a continuous supply of moisture that strengthens the storm. Over land this moisture supply is cut off, so the storm dissipates. Torrential rain and the highest wind speeds occur in the eye wall, the zone surrounding the calm eye. Here air spirals up strongly to the tropopause, with intense condensation and cloud formation. Winds reach maximum velocity, as high as 250 km per hour, and torrential rain falls. The eye itself is a calm region with subsiding air.