Chapter 8: Solar Radiation, Heat Balance and Temperature

Exercises — Exercises

Q1 Multiple choice. The sun is directly overhead at noon on 21st June at: (a) The equator (b) 23.5° S (c) 23.5° N (d) 66.5° N

(c) 23.5° N. On 21st June, the summer solstice, the sun's vertical rays fall on the Tropic of Cancer, which lies at 23.5° N.

Q2 Multiple choice. In which one of the following cities are the days the longest? (a) Tiruvanantpuram (b) Chandigarh (c) Hyderabad (d) Nagpur

(b) Chandigarh. It lies farthest north of the four cities. In the northern hemisphere summer, day length increases with latitude because of the tilt of the earth's axis, so the highest-latitude city has the longest days.

Q3 Multiple choice. The atmosphere is mainly heated by the: (a) Short wave solar radiation (b) Reflected solar radiation (c) Long wave terrestrial radiation (d) Scattered solar radiation

(c) Long wave terrestrial radiation. The atmosphere is largely transparent to short-wave insolation. The heated earth radiates long-wave energy, which gases like carbon dioxide absorb, so the atmosphere is heated indirectly from below.

Q4 Make correct pairs from the following two columns. (i) Insolation (ii) Albedo (iii) Isotherm (iv) Annual range; with (a) The difference between the mean temperature of the warmest and the coldest months (b) The lines joining the places of equal temperature (c) The incoming solar radiation (d) The percentage of visible light reflected by an object

(i)-(c): insolation is the incoming solar radiation. (ii)-(d): albedo is the share of radiation reflected by an object or surface. (iii)-(b): isotherms join places of equal temperature. (iv)-(a): annual range is the difference between the mean temperatures of the warmest and coldest months.

Q5 Multiple choice. The main reason that the earth experiences highest temperatures in the subtropics in the northern hemisphere rather than at the equator is: (a) Subtropical areas tend to have less cloud cover than equatorial areas. (b) Subtropical areas have longer day hours in the summer than the equatorial. (c) Subtropical areas have an enhanced "green house effect" compared to equatorial areas. (d) Subtropical areas are nearer to the oceanic areas than the equatorial locations.

(a) Subtropical areas tend to have less cloud cover than equatorial areas. Maximum insolation is received over the subtropical deserts, where cloudiness is least, so the equator receives comparatively less insolation than the tropics.

Q6 How does the unequal distribution of heat over the planet earth in space and time cause variations in weather and climate? (about 30 words)

Different parts of the earth receive different amounts of heat at different times. This creates pressure differences in the atmosphere, which drive winds that carry heat from one region to another. These variations in heat, pressure and wind produce differences in weather and climate.

Q7 What are the factors that control temperature distribution on the surface of the earth? (about 30 words)

Temperature depends on the latitude of the place, its altitude, its distance from the sea, air-mass circulation, the presence of warm and cold ocean currents, and local aspects. Latitude governs the insolation received, while altitude lowers temperature at the normal lapse rate.

Q8 In India, why is the day temperature maximum in May and why not after the summer solstice? (about 30 words)

In May the sun's rays are nearly vertical over India, days are long and skies are largely clear, so insolation and surface heating are high. After the solstice the monsoon brings thick cloud cover, which reflects and absorbs insolation, so day temperatures fall.

Q9 Why is the annual range of temperature high in the Siberian plains? (about 30 words)

Siberia is a large continental interior at high latitude. Land heats and cools quickly, and there is no moderating influence of the sea. Summers are warm and winters extremely cold, so the annual range exceeds 60 °C, an effect of continentality.

Q10 How do the latitude and the tilt in the axis of rotation of the earth affect the amount of radiation received at the earth's surface? (about 150 words)

The earth is a geoid, so the sun's rays strike different latitudes at different angles. Near the equator and tropics the rays are nearly vertical, covering a small area, so energy per unit area is high and the rays pass through less atmosphere, with less absorption, scattering and diffusion. At higher latitudes the rays are slant, spread over a larger area and travel through a greater depth of atmosphere, so a smaller amount reaches the surface. Insolation therefore generally decreases from the tropics towards the poles. The earth's axis makes an angle of 66½° with the plane of its orbit. Because of this tilt, the latitude receiving vertical rays shifts through the year, and day length and angle of the rays change with the seasons. In winter the middle and higher latitudes receive less radiation than in summer, so the tilt strongly influences insolation at different latitudes.

Q11 Discuss the processes through which the earth-atmosphere system maintains heat balance. (about 150 words)

The earth neither warms up nor cools over time, because heat received equals heat lost. Taking insolation at the top of the atmosphere as 100 units, about 35 units are reflected back to space before reaching the surface: 27 from cloud tops, 2 from snow and ice, and the rest by scattering. This is the earth's albedo. The remaining 65 units are absorbed: 14 by the atmosphere and 51 by the earth's surface. The surface radiates back 51 units as terrestrial radiation. Of these, 17 units go directly to space and 34 are absorbed by the atmosphere, through direct absorption, convection and turbulence, and latent heat of condensation. The atmosphere thus holds 48 units (14 from insolation and 34 from terrestrial radiation) and radiates them to space. Total returning radiation is 17 + 48 = 65 units, balancing the 65 units absorbed. Surplus heat from the tropics is also carried poleward, so the heat budget stays balanced.

Q12 Compare the global distribution of temperature in January over the northern and the southern hemisphere of the earth. (about 150 words)

Temperature distribution is shown by isotherms. In January the effect of latitude is clear, but deviations from the latitudinal trend are greater in the northern hemisphere, where land area is much larger. There, isotherms bend north over the oceans, because warm currents like the Gulf Stream and North Atlantic Drift warm the North Atlantic, and bend south over the continents, where temperatures fall sharply, notably in Europe. The effect is most pronounced in the Siberian plain, where the mean January temperature along 60° E is minus 20 °C at both 80° N and 50° N. Mean January temperatures are over 27 °C in the equatorial oceans, over 24 °C in the tropics, 2 °C to 0 °C in the middle latitudes and –18 °C to –48 °C in the Eurasian interior. In the southern hemisphere the ocean dominates, so isotherms run more or less parallel to the latitudes and temperature varies more gradually. The 20 °C, 10 °C and 0 °C isotherms run parallel to 35° S, 45° S and 60° S.