Topic C1.6: The changing world

Summary

When the **Earth** was formed (about 4.6 billion years ago) it was initially very hot and molten, so the more dense material sunk to the centre and the less dense material collected at the surface. As heat escaped into space, the surface cooled quicker than the core and formed a solid crust. Scientists originally thought that features on the earth's surface such as mountain ranges were caused by the shrivelling of the crust as it cooled. Since that time the earth has continued to lose heat but this is balanced by heat from the sun and heat generated by radioactive decay in material below the crust in the regions known as the mantle and the core. The composition and density of the inner parts of the earth is determined by studying the way in which seismic waves (from earthquakes) are affected as they pass through the earth from one point on the surface to another.

The **crust** varies in thickness from about 5 km under the oceans up to about 50 km under continents.

The **mantle** has a thickness of about 3000 km and makes up most of the volume of the earth. The temperature in the mantle is high enough to melt rocks in the crust but because of the high pressures, the rocks exist in a kind of plastic state – not really a liquid but able to flow very slowly in convection currents due to temperature variations.

The Earth's **core** consists mainly of the metal iron with some nickel. The outer core is liquid and the inner core is solid (due to high pressures) – together they have a radius of about 3500 km. The flow of molten iron in the outer core is thought to give rise to the earth's magnetic field.

The crust and the upper part of the mantle is cracked into a number of different **tectonic plates** which move independently as they are carried a few centimetres per year by convection currents in the mantle. Originally these plates formed a single land mass known as Pangaea but these have now drifted apart to form today's continents. Plates which were originally in close proximity show complementary shapes (*e.g.* the east coast of S. America and the west coast of Africa) and have similar rock types and fossil records. As plates move together or apart, huge pressures build up at the boundaries leading to earthquakes (which may cause tsunamis if they occur below the sea), volcanic activity (molten magma rising through gaps in the crust), and folding of rock strata to form mountain ranges.

Four billion years ago, the earth's **atmosphere** consisted of gases released by volcanic activity from the hot rocks in the mantle and crust – mainly water vapour, carbon dioxide and nitrogen with some methane and ammonia. As the earth cooled, most of the water vapour condensed to form a liquid and much of the carbon dioxide dissolved in the resulting oceans. Three billion years ago, plants began to grow in the oceans resulting in the removal of carbon dioxide from the atmosphere and the formation of oxygen through **photosynthesis**. When living things died, some of the carbon-containing compounds they contained were converted over millions of years into **fossil fuels** (coal, oil, natural gas) or **sedimentary rocks** (such as limestone) thus removing more CO_2 from the atmosphere. In the upper atmosphere, radiation from the sun converted some oxygen into ozone (O_3 – which absorbs harmful ultra-violet rays from the sun) and allowed life to develop on land from about 0.5 billion years ago. Once the levels of plant and animal life had become balanced (about 200 million years ago), the levels of the major gases in the atmosphere – nitrogen (78%), oxygen (21%) and argon (1%) – stabilised and have remained more or less constant until the present day.

Over the last few centuries, man has reduced the amount of vegetation on the planet so the system has become unbalanced and more carbon dioxide is produced by animals than is consumed by plants. Some of this excess is absorbed by the oceans but there has been a gradual increase in the quantity of CO_2 in the atmosphere. This is made worse by the burning of fossil fuels which also releases CO_2 into the atmosphere.

Carbon dioxide absorbs heat radiated from the surface of the earth and prevents it escaping into space. This is known as the **greenhouse effect**. As the quantity of CO_2 in the atmosphere increases, the effect is magnified and average temperature of the earth increases, leading to **global warming**. This may lead to ice-caps and glaciers melting, changes in ocean currents and air streams and consequent major **climate change**.

Argon is a **noble gas** from Group 0 in the Periodic Table. It is very unreactive and is used to provide an atmosphere where the presence of oxygen would lead to oxidation such as electric light bulbs. Noble gases are also used in discharge tubes to provide coloured light (e.g. neon lights). Helium has a very low density and is used in balloons.

One other problem caused by gases released by human activity is the **depletion of the ozone layer**. This is caused by gases such as chlorofluorocarbons (CFCs) and oxides of nitrogen (from jet engines) which react with the ozone, turning it back into oxygen. As ozone protects life on earth from the dangerous ultra violet rays of the sun, any depletion could have severe effects on the viability of organisms. CFCs have been used as aerosol propellants and refrigerants but have now largely been replaced by safer alternatives.

Other gases produced by industrial processes, such as oxides of sulphur and nitrogen, dissolve in water droplets in clouds and fall as **acid rain**. This can cause severe damage to vegetation which is intolerant of acidic conditions and on organisms further down the food chain. It also corrodes limestone and damages buildings.