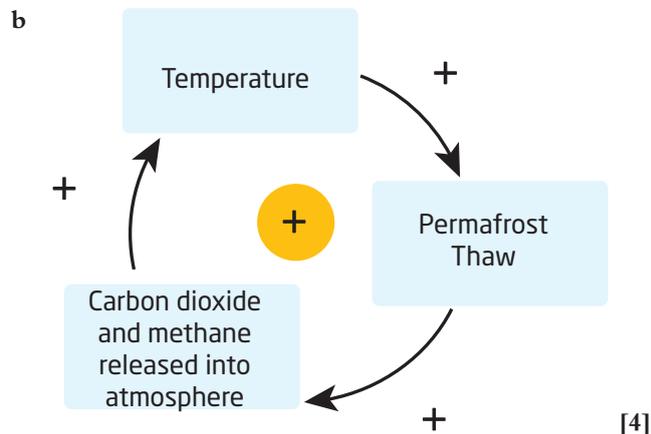


Answers to end-of-topic questions

Topic 1

- 1 a A model is a simplified description, that shows the structure or working of a system [2]
- b i Models can track the changes in climate temperature; correlate them with the proportion of carbon dioxide in the atmosphere: these data can be extrapolated to predict future trends. [3]
- ii (any 3) Effectiveness of carbon-emission reduction on different processes can be monitored and predictions made; but data available will be relatively short term; therefore may not be reliable; new technology may improve our ability to reduce carbon emissions. [3]

- 2 a Negative feedback is a self-regulating method which leads to the maintenance of a steady state, whereas positive feedback leads to increasing change in a system. [2]



- c Natural systems are open and stable systems; negative feedback maintains stability of these systems; without internal control an ecosystem could not be self-sustaining [2]
- 3 a i Energy cannot be created or destroyed but it can be converted from one form to another. [1]
- ii Output = 7650 kJ (10 000 – 1000 = 9000; 15% of 9000 = 1350; to output = 9000 – 1350 = 7650) [2]
[1 mark for answer + 1 mark for working out]
- b i 25 units; To next trophic level/trophic level 3/to carnivores
- ii Lost as heat

- 4 Inputs: (any 3) light, rain, seeds, labour; soil; water; technology
- Processes: (any 3) planting, ploughing, harvesting; respiration
- Outputs: (any 3) wheat, heat, carbon dioxide, oxygen, food, income, waste products
- [1 mark for each correct answer]

- 5 a Despite apparently caring for the environment, the individual is still driving a large car which is producing more greenhouse gas; the message is that individuals should consider all aspects of their life styles. [2]
- b EVS is a particular worldview or set of paradigms that shapes the way a person (or society) evaluates environmental issues. [1]
- c (any 2) A technocentrist would seek technological or innovative solutions; such as carbon dioxide capture; and/or storage; seek new technology to reduce carbon emissions. [2]
- (any 2) An ecocentrist would highlight the overuse of fossil fuels; seek restrictions on emissions; aim for sustainability; monitor the production of carbon dioxide; encourage individuals to impose restraints on emissions. [2]

- 6 a The first quotation seems to indicate that humans can use the resources of the Earth however they please; they should not be shared out by any one powerful person. This view might be supported by a technocentrist who would seek to use all available resources.
- An ecocentrist would probably agree with the second quotation since they believe that people should seek to minimise their impact on the Earth and use only what is absolutely necessary. Or other suitable arguments.

[1 mark for suggestions; 2 marks for justifying the viewpoint]

- b i (any 5) Wealthier countries are more likely to invest in environmental protection because: it is expensive to adapt to environmentally sustainable technology such as wind power; carbon trading will benefit MEDCs because they can afford to buy from LEDCs; LEDCs may have less effective environmental laws than MEDCs; because they want to encourage companies to set up; and to provide employment;

Answers to end-of-topic questions

Many LEDCs have smaller ecological footprints than MEDCs; people in LEDCs are often more environmentally aware (e.g. native peoples of the rainforest); people in LEDCs are more dependent on the environment so it is important to help protect it (e.g. Madagascar).

[1 mark for each point clearly made and justified]

- ii The value of education to a society varies from society to society. One society may value environmental education whereas another may regard the environment only as a source of resources.

Some societies regard a pleasant view as a luxury which all should be able to enjoy, whereas others consider that survival is more important (OWTTE). **[2]**

Topic 2

- 1 a Mouse, cricket, rabbit, deer (*any three*). **[1 mark each]**

b Mountain lions, because rabbit and deer are their only sources of food. **[1]** Deer breed more slowly than rabbits and their population is likely to be smaller. The hawk might also be affected, but it has two alternative sources of food (snakes and mice). **[1]**

c **[2 marks both lines must be shown correctly]**

d One, the hawk. **[1]**

- 2 a There is the greatest amount of living plant biomass in the tropical rainforest, and the least in the coniferous forest. The tropical rainforest contains twice as much as the same area of coniferous forest. **[1]**

b The tropical rainforest produces more than three times as much new plant material per unit area as the deciduous forest, and more than four times as much as the coniferous forest. **[2]**

c Not all the new plant material (biomass) produced in a year becomes leaf litter. Some of it will be eaten by herbivores and not fall to the ground. Some of it, such as wood, will remain as part of the plant and add to its overall biomass. **[2]**

- d *Any three of the following points:*

The increase in living biomass in the rainforest is greater than in either of the two other forests. **[1]**

Rainforest produces a 6 per cent increase in new plant material, whereas the deciduous forest produces only 2 per cent and the coniferous forest 2.6 per cent. **[1]**

If plant biomass was harvested from the rainforest, it would recover more quickly than the other two systems. **[1]**

The quantity of material taken would have to be sustainable – that is, not exceed the amount that the forest could replace (a sustainable yield). **[1]**

The rainforest has the highest productivity, but other factors such as accessibility and conservation issues might make it less useful. **[1]**

- 3 a An ecosystem is a community of interdependent organisms and the physical (abiotic) environment in which they live. **[2]**

b i A pyramid of biomass is a diagram used to show the amount of living material present at each trophic level in an ecosystem. It is constructed by measuring the amount of dry mass in samples of the organisms present. **[2]**

ii Abiotic factors are non-living components of an ecosystem; examples include temperature, rainfall, soil pH and soil type (*or other suitable examples*). **[2]**

iii Succession is the process in which communities in a particular area change over a period of time, so that the appearance of the whole area evolves and changes. **[2]**

- 4 a If weeds are not removed from the sample areas, the pea plants are unable to grow and their yield is very small because of competition from the weeds. If weeds are removed, pea plants grow well and the yield is high; weeds compete with the peas for nutrients and light; weeds are likely to be faster growing than the peas and to outcompete them if they are not removed. **[any 3, 1 mark each]**

b Farmers must remove weeds from their fields to increase their yields, but weeding takes time and uses energy (if it is mechanised) or chemicals, which may be expensive; weeding is important, but as the graph shows it is not necessary to remove every weed, as the yield with six weeks of weeding is high; farmers must balance cost and benefit. **[1 mark for each of the 3 statements]**

c Biomass can be estimated by sampling areas of the field; a random number grid and quadrats should be used to select areas so that human bias is not a factor; **[1]** all the weeds [including roots] in the sample quadrat should be removed, rinsed and dried to constant mass in an oven; **[1]** the mass of weeds in the large field can be obtained by multiplication. **[1]**

- 5 a Increase, because there will be more organisms present as a succession proceeds, and more will die and be recycled adding nutrients. **[2]**

b Increase – as the succession develops, more niches will be available as the complexity of the environment increases. **[2]**

c Increase – more organisms and diversity will result in more growth of those organisms and more biomass. **[2]**

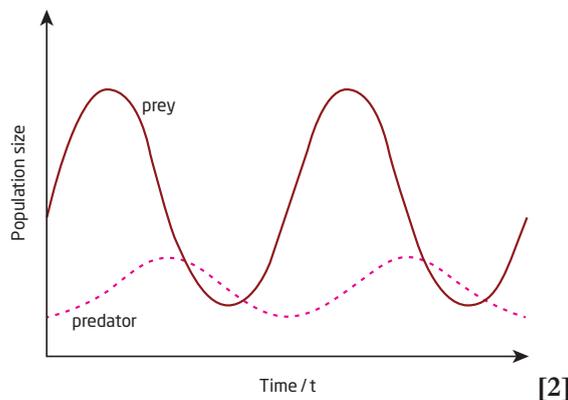
- d Productivity – the energy produced by producers – will increase and the biomass gained by consumers will also increase. [2]
 [in each case 1 mark for the correct answer and 1 for the explanation]

- 6 a i *r*-strategists produce large numbers of offspring and have a short lifespan, whereas *K*-strategists are long-lived and produce few offspring. [2]
 ii (any 2) suitable example (frogs, fish, weed plant); advantages: can take advantage of unstable or changing environments; parents do not care for their young; large numbers produced so that a few survive to maturity. [2]
 iii *K*-strategists tend to reproduce slowly and have few offspring, so take a long time/may not recover following a disturbance. [1]

b i

Time / min	Population numbers
0	1
20	2
40	4
60	8
80	16
100	32
120	64
140	128
160	256

- ii Graph with axes correctly labelled: time/min; population number; graph shows an exponential increase in the population.



- iii The curve would level off; enter the lag phase and then the plateau phase; as nutrients ran out/waste accumulated; the population would stop increasing; eventually bacteria would die. [3]

Topic 3

- 1 a i The tectonic plate on which Australia is found separated from other continents over 50 million years ago. The Australian land mass has indigenous species that have developed differently from species elsewhere because of this separation. The result is a range of species with unusual characteristics that are not found anywhere else in the world. [2]
 ii (any 3) Isolation can lead to speciation; because interbreeding and exchange of genes with other populations is not possible; isolated populations adapt to their environment; so new species may form (e.g. the Galapagos Islands/Australia). [3]
 iii A species tends to produce more offspring than are able to survive; the best adapted (fittest) outcompete other individuals; the fittest survive and breed; passing on their genes to the next generation; over time more individuals in the population have these favourable traits and the population gradually changes; eventually, if the population is isolated, it may become different from the original species. [4]
- b i Species diversity is the variety of species per unit area, including both the number and relative abundance of species. [1]
 ii Habitat diversity is the range of different habitats in an ecosystem. [1]
- 2 a Species-based conservation can favour high-profile species; it is less successful for unattractive organisms; but preserving the habitat of a high-profile species means conserving habitat, which will benefit all species; some species can be maintained in zoos or seed banks. [3]
 b Answers must be related to a *specific* ecosystem. (any 5) Hunting for food; collecting specimens for medicine or pets; harvesting plants or fish; habitat loss or degradation; introduction of non-native (invasive) species; establishment of monoculture; natural hazards (e.g. volcanoes, tsunamis). [5]
 c A large reserve contains more habitats; and species than a small one; a large reserve has less edge effect; large reserves have greater populations of individual species than small ones so genetic diversity is greater; a rounded shape is better than a long, thin shape of the same area because it has lower edge effect. [4]
 d Advantages: (any 2) corridors allow gene flow between two protected areas; they allow seasonal movements to take place; they reduce accidents on roads which separate protected areas. [2]
 Disadvantages: (any 2) can allow hunters to move easily between protected areas; may allow the spread of disease or pests; can cause an increase in edge effect. [2]

Answers to end-of-topic questions

- 3 a i (any 3) Narrow geographical range; small or declining population; low population density; low reproductive potential; few populations of the species; very specialised feeding habits. [3]
- ii Past extinctions caused by abiotic events such as volcanoes, earthquake or meteor strike, current extinctions due to biotic (human) factors; past extinctions occurred over a long period of time, current extinction is happening in hundreds not millions of years. [2]
- b i (any 3) Population size, numbers of mature individuals; geographic range; quality of habitat; probability of extinction. [3]
- ii (any 3) Whale population reduced by hunting; hunting has reduced the numbers of breeding adults so population not able to replenish its numbers; disturbances to feeding grounds caused by oil wells/drilling; whales have been caught in fishing gear; collisions with ships; underwater noise; or other suitable examples. [3]
- 4 a The group in the area which received extra food. [1]
- b If predators were excluded as well as the extra food, the mass was lower, so with food only there was some predation and the remaining squirrels each received more food. [1]
- c Heavier females are likely to be more successful in reproduction and will influence the population size. [1]
- d 22 ± 1 . [1]
- e The numbers of squirrels per hectare in the two areas where food had been provided fell to the same values as in the control area and the area where predators had been excluded. [2]
- f Capture–mark–recapture. [1]

Topic 4

- 1 a Stores are places where water is held. Transfers are where water is flowing through the drainage basin system. [2]
- b Urbanisation can considerably increase the proportion of precipitation that is converted to surface runoff. Urbanisation replaces permeable vegetated surfaces with impermeable surfaces of concrete, tarmac, brick and tiles. Where open spaces exist in urban areas in parks, commons and other open land, the soil is often heavily compacted due to high recreational use.
- Urban systems are designed to move water off buildings, roads and other surfaces as quickly as possible. Think of the way buildings are designed to move water away rapidly – pitched roofs, gutters, water downpipes and

drains. Most roads have a camber, or curvature to the surface, that helps water drain off them into drains at the sides of roads, rather than pooling in the centre of the road and making driving difficult.

All these actions drastically reduce infiltration and increase surface runoff. As a result, water moves into river systems much more quickly than before, increasing the risk of flooding. The increasing size of many urban areas has increased the potential for flash floods. Flash flooding happens when precipitation falls so fast that the underlying ground cannot cope, or drain it away, fast enough. With flash flooding there is often little time between the precipitation falling and flash flooding occurring. Flash floods are capable of inundating roads, undermining buildings and bridges, tearing out trees, and scouring new channels. [4]

- 2 a Water security is the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being and socioeconomic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability. [2]
- b The main physical factors influencing access to safe drinking water are: the amount of precipitation in a region; the seasonal distribution of precipitation; the physical ability of the surface area to store water; the rate of evapotranspiration; the density of surface access points to water; the ease of access to groundwater supplies if they exist.

The main human factors are: the wealth of a country in terms of its ability to afford water infrastructure; the distribution of population between urban and rural areas, with the concentration of investment in water infrastructure in urban areas; socioeconomic differences in urban areas – affluent urban districts invariably have better access to safe water than poor districts have; the degree of contamination of urban and rural water supplies; civil war and international conflict. [4]

- 3 a A coastal area of the Gulf of Mexico where the water contains so little oxygen that living organisms cannot survive. It is a dead zone. [1]
- b Effluent from the land poured into the Gulf of Mexico and caused eutrophication, which in turn led to increased biochemical oxygen demand and eventually the death of organisms that used to live there. [3]
- 4 a There is a correlation between the toxic releases and income of the residents in the areas where the toxic releases occur. There are more toxic releases in areas where incomes are low, and fewer in wealthier areas. [2]

- b** Toxic releases tend to come from factories and industrial areas, and it is likely that lower income households will be located nearby because workers in the factories live there; factories tend to be built close to other factories, and this increases the releases from those areas. [2]
- c** Education of factory management; legislation to regulate release of toxic materials; cleaning of waste before it is released (*or other suitable examples*). [3]
- 5 a** Excess nutrients cause excess growth of algae (algal blooms); algal blooms deprive lower layers of water of light, so plants die; numbers of bacteria increase to decompose the algae, and use oxygen from the water so that fish and other species also die.
- b** Humans release nitrates and phosphates into waterways as they use fertilisers or produce sewage.
- c** It reduces biodiversity; it changes the types of species that occur in an aquatic system; it reduces oxygen content of the water so that only pollution-tolerant organisms can survive.

Topic 5

- 1 a** The Food Security Risk Index is attempting to show the degree of food security risk according to four classes from low risk to extreme risk. [2]
- b** The countries with high and extreme high risk are mainly located in Africa, the Middle East, Asia and Latin America. [3]
- c** The countries at low risk are in North America, most of Europe, Australia, New Zealand, Japan and Chile. [3]
- 2 a** Soil is the naturally occurring unconsolidated material on the surface of the Earth that has been influenced by parent material, climate, macroorganisms and microorganisms, and relief, all acting over a period of time. It is thus a mixture of inorganic mineral particles and organic material from decomposed flora and fauna that covers the underlying bedrock, and in which a wide variety of terrestrial plants grow. [4]
- b** Loam is composed of sand, silt and clay in about 40–40–20 per cent concentrations respectively, but this can vary. Different proportions of sand, silt and clay give rise to types of loam soils: sandy loam, silty loam, clay loam, sandy clay loam, silty clay loam, and loam.
- Loams have greater cohesion than sandy soils and hold together better when a handful is picked up. They are soft and rich to the touch. Generally containing more nutrients and humus than sandy soils, loams have better infiltration and drainage than silty soils. While drainage is good, this type of soil retains sufficient amounts of water. Loams are easier to cultivate than clay soils and thus a very popular option with farmers and gardeners. Loamy soils may be wet in winter as water tables rise but are usually well drained in summer. [3]
- 3 a** Deforestation and overgrazing are major processes that have had a huge impact on soil fertility.
- Deforestation occurs for a number of reasons, including the clearing of land for agricultural use, for timber, and for other activities such as mining. Such activities tend to happen quickly, whereas the loss of vegetation for fuel wood, a massive problem in many developing countries, is generally a more gradual process. Deforestation means that rain is no longer intercepted by vegetation, with rain splash loosening the topsoil and leaving it vulnerable to removal by overland flow.
- Overgrazing is the grazing of natural pastures at stocking intensities above the livestock carrying capacity. Population pressure in many areas and poor agricultural practices have resulted in serious overgrazing. This is a major problem in many parts of the world, particularly in marginal ecosystems. [4]
- b** Various cropping techniques can be employed to reduce soil degradation. These include:
- Contour ploughing – a tried and trusted technique which prevents or diminishes the downslope movement of water and soil.
 - Terracing. Where slopes are too steep for contour ploughing, terracing may be practised. Here the steep slope is converted into a series of flat steps with raised outer edges (bunds). Some studies have concluded that terracing can reduce erosion 20-fold.
 - Converting land from arable to pastoral uses – the planting of grass helps to bind soil particles together, reducing the action of wind and rain compared with the effect on bare soil surfaces.
 - Including grasses in crop rotations.
 - Leaving unploughed grass strips between ploughed fields.
 - Keeping a crop cover on the soil for as long as possible, thus minimising the ‘bare soil’ period.
 - Selecting and using farm machinery carefully – in particular, avoiding where possible the use of heavy machinery on wet soils, to prevent damage to the soil structure, and using low ground pressure set-ups on machinery when available.
 - Leaving the stubble and root structure in place after harvesting.
- All of these techniques have a proven track record in reducing soil degradation, with very few disadvantages.
- Wind-reduction techniques have been employed over a long period to conserve soil. The planting of trees in shelter belts and the use of hedgerows can do much to dissipate the impact of strong winds, reducing the wind’s

Answers to end-of-topic questions

ability to disturb topsoil and erode particles. Shelter belts shelter the soil by reducing wind and evaporation and thus increasing soil temperature. They provide roots at the boundaries of the field, supplying valuable organic matter. Hedgerows provide a habitat for a whole range of animal life, adding to the general fertility of the fields or parcels of land they surround. Research in the Philippines and elsewhere has shown that hedgerows have proved very effective in reducing soil erosion.

Strip cultivation can also reduce wind erosion significantly. Strip cultivation is the growing of crops in a systematic arrangement of strips across a field. The strips are arranged at right angles to the direction of the prevailing wind for maximum effectiveness. The strips are arranged so that a close-growing crop or strip of grass is alternated with a strip with less protective cover. [4]

- 4 a The FAO estimates that one-third of food produced annually for human consumption worldwide is lost or wasted along the chain that stretches from farms to food-processing factories, marketplaces, retailers, restaurants and household kitchens. This is enough sustenance to feed 3 billion people. Twenty-eight per cent of the world's agricultural area is used to produce food that is lost or wasted. However, the problem does not end here. Most food waste ends up in landfill, representing a large part of municipal solid waste. Methane emissions from landfill are a significant source of greenhouse gas emissions. The carbon footprint from food waste is estimated at 3.3 billion tonnes of CO₂ equivalent released into the atmosphere each year. The total volume of water used each year to produce food that is lost or wasted is equivalent to three times the volume of Lake Geneva. [3]
- b Food waste occurs towards the end of the food chain, at the retail and consumer level. In general, the richer the nation, the higher its per-capita rate of food waste. In contrast, food loss occurs mainly at the front of the food chain, during production, post-harvest and processing. Food loss is less prevalent in MEDCs than in LEDCs. The latter tend to lack the infrastructure to deliver all of their food in good condition to consumers. In Africa, with limited storage facilities, refrigeration and transportation, 10–20 per cent of the continent's sub-Saharan grain is lost to hazards such as mould, insects and rodents. Facing similar challenges, India loses an estimated 35–40 per cent of its fruit and vegetables. [4]

30 per cent. This means that 30 per cent of incoming solar radiation is reflected back into space. It has been estimated that, if all clouds were removed from the atmosphere, global albedo would fall to around 15 per cent. Thus global cloud cover has a clear overall cooling effect on the planet.

However, although cloud cover reduces the level of insolation reaching the Earth's surface, it also reduces the amount leaving it. Rainforest areas astride the equator characterised by thick cloud cover experience days of about 30°C and nights of about 20°C. In contrast, temperatures in desert regions, where cloud cover is little, might reach 40°C during the day and drop to around freezing point at night. This huge difference is because humid air absorbs heat by day and retains it at night. [4]

- 2 a Most of the ozone in the atmosphere is in the stratosphere, with only about 10 per cent in the troposphere. The ozone layer is an area of high concentration in the stratosphere, with a maximum concentration at an altitude of about 20–25 km. The fall-off in ozone concentration either side of this altitudinal range is steep on both sides. The ozone in the troposphere is concentrated near the Earth's surface. [2]
- b It absorbs most of the biologically damaging ultraviolet sunlight, allowing only a limited amount to reach the Earth's surface. [1]
- c Ozone depletion can be the result of natural causes such as volcanic eruptions. However, the impact of human activity has caused by far the greatest destruction of ozone. Ozone-depleting substances, which are generally the result of human economic activity, have had a considerable impact on stratospheric ozone. Most of these substances contain the halogens chlorine, fluorine and bromine. The halogens are contained in industrial products such as CFCs, hydrochlorofluorocarbons, halons and methyl bromide.

Halogenated organic gases are very stable under normal conditions, but they can liberate halogen atoms when exposed to ultraviolet radiation in the stratosphere. These atoms react with monatomic oxygen and slow the rate of ozone re-formation. Such pollutants enhance the destruction of ozone, thus disturbing the equilibrium of the ozone production system. [3]

- d The Montreal Protocol on Substances that Deplete the Ozone Layer was negotiated and signed in September 1987. The Montreal Protocol has reduced the worldwide stock of CFCs and other ozone-destroying compounds by 98 per cent. CFCs have largely disappeared from the computer manufacturing process, polystyrene packing materials and disposable cups, refrigerators, car and home air conditioners, aerosol sprays, fire extinguishers, degreasing compounds and foam ingredients in furniture. The use of other ozone-depleting substances has also declined significantly.

Topic 6

- 1 Most clouds form in the troposphere, where they reflect and absorb a significant amount of incoming solar radiation. Cloud albedo is a measure of the reflectivity of a cloud. High values mean that a cloud can reflect more solar radiation. Cloud albedo can vary from less than 10 per cent to more than 90 per cent. The overall albedo of the Earth is about

The Montreal Protocol was one of the first international agreements that included the potential use of trade sanctions to achieve the objectives of the treaty. It also offered significant incentives for non-signatory countries to sign the agreement. [4]

- 3 Most cases of serious photochemical smog are associated with temperature inversions close to the Earth's surface. A temperature inversion is where temperature increases with altitude, trapping the cooler and more dense polluted air below.

Topography may also be a significant factor. Urban areas located in valleys with surrounding upland areas tend to experience low air circulation and a high level of accumulation of air pollutants compared with cities situated in more open landscapes.

The pattern of wind can affect the frequency of the replacement of local air with fresh air from outside the urban area. Calm atmospheric conditions associated with anticyclones mean that photochemical smog tends to stagnate over urban areas for some time. [4]

Large-scale burning associated with deforestation can contribute significantly to smog in urban areas.

- 4 a Acid deposition refers to the mix of air pollutants that together lead to the acidification of freshwater bodies and soils. It can be subdivided into dry deposition and wet deposition. [1]
- b Acid deposition does not usually kill trees quickly. Rather, it is more likely to weaken trees by damaging their leaves, limiting the nutrients available to them, or poisoning them with toxic substances slowly released from the soil. Sulfur dioxide interferes with the process of photosynthesis. When acid deposition is frequent, leaves tend to lose their protective waxy coating. Leaves and pine needles turn brown and fall off. Once trees are weak, they can be more easily attacked by diseases or insects that ultimately kill them. Weakened trees may also become injured more easily by cold weather. Coniferous trees are often most at risk from acid rain.
- High aluminium concentrations in soil due to acid deposition can prevent the use of nutrients by plants. Acid rain which has seeped into the ground can poison vegetation with toxic substances that are slowly absorbed through the roots. [3]

Topic 7

- 1 Energy security can be defined as the uninterrupted availability of energy sources at an affordable price. It depends on an adequate and reliable supply of energy providing a degree of independence. An inequitable availability and uneven distribution of energy may lead to conflict.

As energy demand has increased, reliance on energy imports has risen. For many countries energy imports account for more than half of their energy requirement, and for some countries they account for over half of their energy requirement. Apart from concerns over the price of energy, there are increasing concerns that supplies might be disrupted for political reasons. Countries such as the USA and China have built up strategic petroleum reserves to tide themselves over for a few months if normal oil supplies are disrupted. There are worries about the vulnerability of energy pathways – the supply routes between producers and consumers – which may be pipelines, shipping routes or electricity cables. For example, most Middle East oil exports go by tanker through the Strait of Hormuz, a relatively narrow body of water between the Persian Gulf and the Gulf of Oman. Roughly 30 per cent of the world's oil supply passes through the strait, making it one of the world's strategically important 'chokepoints' (a route that it would not be difficult to block in times of conflict). [4]

- 2 a Between 1990 and 2009 total emissions increased by 451.4MMT carbon dioxide equivalents, a relative increase of 7.3 per cent. [1]
- b Deindustrialisation, with many heavy industries shifting to newly industrialised countries; increasing investment in emissions-control technology. [2]
- c Despite a reduction in the average emissions per vehicle, the considerable increase in the number of vehicles on US roads has resulted in this significant increase in emissions. [2]
- d A high per-capita demand for electricity in the USA; heavy reliance on burning fossil fuels, particularly coal, for electricity production. This is a polluting industry that needs to invest much more in controlling emissions. [2]
- 3 Geoengineering is deliberate large-scale intervention in the Earth's natural systems to counteract climate change. Geoengineering techniques can be grouped into two categories: solar radiation management and CDR. Solar radiation management techniques include stratospheric aerosols, albedo enhancement and space reflectors. CDR techniques include afforestation, ambient air capture, CCS and biochar. The effectiveness and cost of such techniques are likely to vary significantly. Geoengineering is a science that is very much in its infancy. While some techniques are viable with current technology, most are still at the theoretical stage with research still in progress. [4]

Topic 8

- 1 a Demographic transition is the historical shift of birth and death rates from high to low levels in a population. [2]

Answers to end-of-topic questions

- b** There are a number of important differences in the way that LEDCs have undergone population change compared with the experiences of most MEDCs before them. In LEDCs, birth rates in stages 1 and 2 were generally higher. About 12 African countries currently have birth rates of 45/1000 or over. Twenty years ago, many more African countries were in this situation. The death rate in LEDCs fell much more steeply, and for different reasons. For example, the rapid introduction of Western medicine, particularly in the form of inoculation against major diseases, has had a huge impact on lowering mortality. However, AIDS has caused the death rate to rise significantly in some countries, particularly in sub-Saharan Africa.

Some LEDCs had much larger base populations, and thus the impact of high growth in stage 2 and the early part of stage 3 has been far greater. No countries that are now classed as MEDCs had populations anywhere near the size of India and China when they entered stage 2 of demographic transition. For those LEDCs in stage 3, the fall in fertility has also been steeper. This has been due mainly to the relatively widespread availability of modern contraception with high levels of reliability.

Also, the relationship between population change and economic development has been much more tenuous in LEDCs. [4]

- 2 a** The four general services provided by natural capital are: provisioning services (products from ecosystems); regulating services (benefits from ecosystem processes); cultural services (non-material benefits from ecosystems); and supporting services (services that allow other services to operate). [2]
- b** Natural capital provides the resources and wealth required for human populations to develop. Thus there is intense competition for many of the resources that make up the Earth's natural capital. Many aspects of natural capital are at, or have gone beyond, the limit of their sustainable use. This is because short-term benefit has often taken precedence over long-term sustainability.

Research has shown that economic growth in an increasing number of countries has been adversely affected by rapid decline of one or more aspects of natural capital. It is becoming increasingly important to

understand the relationship between economic growth and natural capital so that intelligent decisions can be made in terms of sustainable development policies.

As we come to appreciate the value of natural capital more than at any time in the past, the need to conserve it and if possible restore it has moved up the political agenda. Improving our understanding of the relationships and trade-offs among forests, soil, biodiversity, water and food production, among other key ecosystem components, is driving new developments in applied scientific research. [4]

- 3 a** The solid waste from households includes the following classes of material: paper, cardboard packaging, glass, metal (mainly cans and foil), plastics, organic waste and e-waste. [2]
- b** Incineration requires a very limited land area compared with landfill, and can be operated in virtually all weather conditions. The process reduces the volume of refuse very significantly. Incineration takes up much less land than landfill. It also has a good resource recovery rate. Over 400 kilowatt hours of energy can be produced by incinerating 1 tonne of waste.

On the debit side, incinerators are expensive to build and operate. Incineration requires a high input of energy, and the tall chimney stacks are viewed by most people as a blot on the landscape. The movement of heavy goods vehicles to and from incinerators is considerable. The ash produced has to be disposed of in landfill. The environmental and health concerns over incineration are long-standing, with sulfur dioxide, nitrogen dioxide, nitrous oxide, carbon dioxide, chlorine, dioxin and particulates being emitted by the process of incineration. However, considerable technological advances have significantly lowered the emission of pollutants into the atmosphere. Thus the environmental impact of incineration varies considerably around the world depending on the age of incinerators.

Incineration is often not feasible in LEDCs because of the high initial construction costs and also because wastes do not have a high enough calorie content to sustain the incineration process – more costly fuel must be added. [4]