

## 2005 AP<sup>®</sup> ENVIRONMENTAL SCIENCE FREE-RESPONSE QUESTIONS

3. Most of the coal mined in the United States today comes from surface (strip) mines. In surface mining, the vegetation, soil, and rock covering the coal (referred to as overburden) are removed and set aside. After the coal has been hauled away, good conservation practices require that the overburden be replaced and the surface be restored to its original condition. Land restoration may be difficult in some regions, due to factors such as the local climate, the thickness of the coal seam, the extent of the overburden, and the sulfur content of the coal.
- (a) Describe the steps that should be taken to restore the land after the overburden has been replaced.
  - (b) Explain why the restoration of the land would likely be more difficult in an arid climate (less than ten inches of precipitation per year).
  - (c) Describe one environmental impact that the sulfur content of the remaining coal and the tailings would have on the reclamation process and suggest a possible remedy.
  - (d) Other than mining and reclamation, describe TWO environmental impacts of using coal for energy.
  - (e) Explain why per capita coal consumption in the United States is likely to increase.
4. The Alaskan National Wildlife Refuge (ANWR) on Alaska's North Slope is frequently in the news because petroleum geologists estimate that there are billions of barrels of economically recoverable oil beneath the surface of its frozen tundra. According to a 1998 United States Geological Survey (USGS) estimate, ANWR could contain up to 10 billion barrels of technically recoverable oil. Oil company officials advocate opening the refuge to oil exploration and the subsequent development of its petroleum resources. Environmentalists argue that oil exploration and development will damage this fragile ecosystem and urge Congress to protect ANWR by designating it as a wilderness area.
- (a) The United States consumes approximately 20 million barrels of oil per day. According to the USGS estimate, for how many days would the technically recoverable oil resource in ANWR supply the total United States demand for oil?
  - (b) Describe TWO characteristics of arctic tundra that make it fragile and explain how these two characteristics make the tundra particularly susceptible to damage from human impacts.
  - (c) Identify TWO activities that would be associated with the development of ANWR petroleum resources and describe a substantial environmental impact of each in ANWR.
  - (d) Identify and describe TWO major end uses of the 20 million barrels of oil that the United States consumes each day and for each use describe a conservation measure that would substantially reduce United States consumption.

**END OF EXAM**

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**Question 3**

Most of the coal mined in the United States today comes from surface (strip) mines. In surface mining, the vegetation, soil, and rock covering the coal (referred to as overburden) are removed and set aside. After the coal has been hauled away, good conservation practices require that the overburden be replaced and the surface be restored to its original condition. Land restoration may be difficult in some regions, due to factors such as the local climate, the thickness of the coal seam, the extent of the overburden, and the sulfur content of the coal.

**(a) Describe the steps that should be taken to restore the land after the overburden has been replaced.**

*(3 points possible)*

*One point is earned for each common step described, up to three.*

**ACCEPTABLE STEPS**

- Recontouring/regrading land to its original topography
- Replacing and/or adding topsoil and/or nutrients as needed to improve soil quality or structure
- Replanting with native vegetation/fast growing species/early successional species
- Monitoring for either 5 or 10 years, depending on location

**(b) Explain why the restoration of the land would likely be more difficult in an arid climate (one with less than 10 inches of precipitation per year).**

*(2 points possible)*

*For biotic or vegetation, 1 point is earned for indicating that it may be difficult to re-establish vegetation due to any of the following factors:*

- low precipitation
- low fertility of soils in arid climates
- water-holding characteristics of soils in arid climates

*For abiotic or consequence, 1 point is earned for indicating that as a consequence of the slow growth of vegetation the reclamation may be prolonged because of*

- wind and/or water-related soil erosion
- runoff
- landslides

**(c) Describe one environmental impact that the sulfur content of the remaining coal and the tailings would have on the reclamation process and suggest a possible remedy.**

*(2 points possible)*

**ACCEPTABLE ENVIRONMENTAL IMPACTS**

*One point is earned for correctly describing that sulfur in the coal and tailings may dissolve in water that percolates through them to form sulfuric acid ( $H_2SO_4$ ) which results in*

- acidification of the surrounding soil
- acidification of groundwater or adjacent bodies of water
- reduced plant growth/animal distribution
- corrosion of roads/drainage culverts
- increased solubility and transport of heavy metals

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**Question 3 (continued)**

**ACCEPTABLE REMEDIES**

*One point is earned for correctly identifying a remedy.*

- Buffer/neutralize with alkaline/basic substances such as limestone (calcium carbonate,  $\text{CaCO}_3$ ), sodium hydroxide ( $\text{NaOH}$ ), sodium bicarbonate ( $\text{NaHCO}_3$ ), and anhydrous ammonia ( $\text{NH}_3$ )
- Cover tailings to reduce contact with precipitation
- Sedimentation ponds/retention basins/catchments
- Bioremediation by sulfate-reducing bacteria

**(d) Other than mining and reclamation, describe TWO environmental impacts of using coal for energy.**  
**(2 points possible)**

*One point is earned for each of the first two acceptable impacts described.*

**ACCEPTABLE EMISSION-RELATED IMPACTS**

- Wet acidic deposition (acid rain, acid precipitation) caused by sulfuric acid ( $\text{H}_2\text{SO}_4$ ) or dry acidic deposition caused by oxides of nitrogen and/or sulfur ( $\text{NO}_x$  or  $\text{SO}_x$ ) resulting from combustion
- Damage to/deterioration of ecosystems due to increased acidification as a result of acidic deposition
- Global climate change (global warming) as a result of the increased release of greenhouse gases (carbon dioxide,  $\text{CO}_2$ , methane,  $\text{CH}_4$ ) from combustion into the atmosphere
- Industrial/photochemical smog as a result of the increased release of the byproducts of combustion
- Environmental pollution from radioactive materials (isotopes of uranium and thorium) released during combustion
- Fallout of heavy metals such as mercury ( $\text{Hg}$ ) and arsenic ( $\text{As}$ ) released during combustion
- Leaching of contaminants from sites where toxic ash resulting from combustion has been disposed
- Human respiratory illness caused by the increased release of particulates/byproducts of combustion
- Thermal pollution

**ACCEPTABLE PROCESSING-RELATED IMPACTS**

- Environmental degradation associated with the transportation of coal
- Environmental degradation associated with building coal-processing facilities
- Aesthetic degradation of the landscape as a result of the power plant or coal-processing facility

**(e) Explain why per capita coal consumption in the United States is likely to increase.**  
**(2 points possible)**

*One point is earned for connecting increased per capita demand for energy to an increased demand for coal because of its*

- lower overall cost compared to other energy sources,
- higher availability in the U.S. than other fossil fuels, or
- suitability as an alternate source of energy necessitated by the reduction (real or projected) in the supply of other energy sources, such as oil.

*One point is earned for connecting an increased per capita demand for energy due to increased affluence of the U.S. population.*

*Note: Simply stating that higher population will result in an increased demand for coal does not earn a point because it does not address the per capita demand.*