MULTIPLE CHOICE

1. ANS: B
   Stratospheric ozone, found roughly 11-16 miles above sea level keeps about 95% of the sun’s harmful UV radiation from reaching the earth’s surface (pp. 467-468, Miller LITE, 17th Ed.).

   TOP: atmosphere & air pollution

2. ANS: B
   Acid deposition, commonly known as acid rain, occurs when emissions from the combustion of fossil fuels and other industrial processes undergo complex chemical reactions in the atmosphere and fall to the earth as wet deposition (rain, snow, cloud, fog) or dry deposition (dry particles, gas). Rain and snow are already naturally acidic, but are only considered problematic when less than a pH of 5.
   http://www.esa.org/education_diversity/pdfDocs/aciddeposition.pdf

   Alternatives A and E will not change the basic problem of acid rain formation or deposition, they will merely change the location of the deposition. Alternative D is a current practice to alleviate the effects of acid deposition, not decrease acid rain and acid deposition. Likewise, alternative C would be (an expensive and difficult) way to mitigate the effects of acid rain and acid deposition.

   TOP: water & land pollution | atmosphere & air pollution

3. ANS: A
   Nitrous Oxide, Methane, carbon dioxide and Chlorofluorocarbons are all greenhouse gases. When heated, these molecules vibrate and release infrared radiation into the lower atmosphere. As this radiation interacts with molecules in the air, it increases their kinetic energy and warms the lower atmosphere and the earth’s surface. Oxygen is not a greenhouse gas (p. 495, Miller LITE, 17th Ed.)

   Note: CFCs (choice E) will confuse students regarding climate change and ozone depletion.

   TOP: atmosphere & air pollution
Once CFC molecules reach the stratosphere, they break down under the influence of high energy UV radiation. This releases highly reactive Chlorine atoms (Cl) that accelerate the breakdown of Ozone (O$_3$) into O$_2$ and O in a cyclic chain of chemical reactions (p. 552, Miller LITE, 17$^{th}$ Ed.) RAR_12Jan11

TOP: atmosphere & air pollution

5. ANS: B

With the exception of B, all the scenarios described in the choices for this question are the consequence of decreased ozone in the stratosphere leading to increased amounts of UV light penetrating the lower atmosphere and earth’s surface.

TOP: atmosphere & air pollution

6. ANS: D

Because ozone reacts strongly with other molecules, high levels of ozone are toxic to living systems. Several studies have documented the harmful effects of ozone on crop production, forest growth, and human health. The substantial negative effects of surface-level tropospheric ozone from this direct toxicity contrast with the benefits of the additional filtering of UV-B radiation that it provides.

http://www.ozonelayer.noaa.gov/science/basics.htm

TOP: atmosphere & air pollution
7. **ANS: A**
   Of the above answers, thermal expansion is the only one that adds to the volume of the ocean causing sea level to rise. Precipitation and evaporation are apart of the water cycle and we can assume as one component changes, all components must change to balance out the cycle. Ocean cooling and the growth of ice caps would decrease the sea level. SR_Summer 2009
   
   This question occurs consistently on the APES exam and requires a basic understanding of physics and chemistry. This questions appeared as part of FRQ 4 in 2010). This is a concept that many APES struggle with, but need to know. RAR_12Jan11.

   **TOP: atmosphere & air pollution | water & land pollution**

8. **ANS: C**

   ![The Greenhouse Effect](http://www.epa.gov/climatechange/kids/greenhouse.html)

   Green house gases, when heated, vibrate and release infrared radiation into the lower atmosphere. As this radiation interacts with molecules in the air, it increases their kinetic energy and warms the lower atmosphere and the earth’s surface. Oxygen is not a green house gas (p. 495, Miller LITE, 17th Ed.) RAR_12Jan11

   **TOP: atmosphere & air pollution**

9. **ANS: E**
   A decrease in snowpack decreases the earth’s albedo (ability of a surface to reflect light). If less light is reflected, then more heat is absorbed at the earth’s surface and in the lower atmosphere. This increased heat absorption contributes to the exacerbate surface warming and sets up a positive feedback loop which may increase snowpack melting and decrease earth’s albedo further. RAR_12Jan11

   **TOP: atmosphere & air pollution**

10. **ANS: D**
    Since 1985, more than 280 new incinerator projects have been delayed or canceled in the US because of high costs, concern over air pollution, and intense citizen opposition. England burns about 90% of its municipal solid waste (MSW) in incinerators compared to 16% in the US and 8% in Canada.

    Students may choose B. Need to be clear that when MSW is combusted in the presence of oxygen, the by product is carbon dioxide, not methane. RAR_12Jan11.

   **TOP: atmosphere & air pollution**
11. ANS: C
Increased UV radiation reaching the earth’s surface from ozone depletion in the stratosphere is harmful to crops and forests. Increased UV light reduces yields for some crops and decreases forest productivity for UV sensitive tree species.

This is a repeat of Question 5, but in this case students are asked to pick the only correct answer. We chose to leave both questions in the exam because they ask students to apply their knowledge of ozone depletion to identify realistic consequences of ozone depletion. Question 5 asks students to identify the incorrect answer.

TOP: atmosphere & air pollution

12. ANS: E
1st auto: 20 mpg /600 miles = 30 gallons
(30 gallons) ¥ (5 pound of carbon) = 150 pounds of carbon total

2nd auto: 30 mpg/600 miles = 20 gallons
(20 gallons) ¥ (5 pounds of carbon) = 100 pounds of carbon total

150 pounds of carbon - 100 pounds of carbon = 50 lbs. of carbon

Simple mathematics, Fair question regarding fuel economy and throws in information about the carbon footprint of one gallon of gas.

TOP: atmosphere & air pollution

13. ANS: D
Combustion of gasoline in an internal combustion engine generates carbon monoxide, VOCs and particulate matter. (pp. 470-471, Miller LITE, 17th Ed.). A more fuel efficient vehicle will combust fewer gallons of gasoline and therefore produce fewer pollutants.

TOP: atmosphere & air pollution

14. ANS: B
According to the 2nd Law of Thermodynamics whenever energy is converted from one form to another in a physical or chemical change, we end up with lower-quality or less useful energy than we started with. (p. 47, Miller LITE, 17th Ed).

TOP: atmosphere & air pollution

15. ANS: B
A decrease in snowpack decreases the earth’s albedo (ability of a surface to reflect light). If less light is reflected, then more heat is absorbed at the earth’s surface and in the lower atmosphere. This increased heat absorption contributes to the exacerbate surface warming and sets up a positive feedback loop which may increase snowpack melting and decrease earth’s albedo further.

TOP: atmosphere & air pollution

16. ANS: D
In the last 100 years, the largest addition of carbon dioxide into the atmosphere has come from human combustion of fossil fuels. Of the main fossil fuels used (coal, oil and natural gas), coal produces the most CO₂, oil produces the second most, while natural gas produces the least CO₂.

TOP: atmosphere & air pollution
17. **ANS: A**

In the southern hemisphere, the south pole is in totally darkness during winter months. In the spring (October in the Southern Hemisphere) the sunlight begins to increase which increases the reaction between the CFC’s and the Ozone in the stratosphere. This is why the ozone hole seems to grow larger during the spring months of the southern hemisphere. The increased sunlight is the catalyst of the reaction.

In 1984, NASA scientists using satellite imagery found that 40-50% of the stratospheric ozone over Antarctica was depleted between October and November. This trend has continued for the past 25 years, however the thinning has decreased somewhat due to international bans on CFCs and other similar compounds (p. 521, Miller LTE, 17th Ed.)

RAR_12Jan11

**TOP: atmosphere & air pollution**

18. **ANS: B**

Acid rain is a generic term that refers to abnormal amounts of sulfuric or nitric acids. Acid rain can result from volcano and decaying vegetation as well as man made activities. Acid rain from man-made activities is largely derived from the combustion of fossil fuels. 2/3 of sulfuric acid and 1/4 of nitric acids are the result of combustion at electric power generation that relies on the burning of fossil fuels.

In the United States older coal-burning power and industrial plants without adequate pollution controls emit the largest amount of pollutants that cause acid deposition. The worst acid deposition in South East Asia occurs in China, which gets 80% of it’s electricity from burning coal (p. 477, Miller LITE, 17th Ed.)

RAR_12Jan11

**TOP: atmosphere & air pollution | water & land pollution**

19. **ANS: C**

The majority of anthropogenic atmospheric Mercury are the generation of electricity in coal-fired powered plants (~65-70%) followed by gold production (~10%) (Side note: Atmospheric mercury is naturally released by volcanoes). SR/RAR_11Jan12.

**TOP: atmosphere & air pollution**

20. **ANS: A**

To calculate the percent increase in anything use the following formula:

\[ \frac{(\text{higher amount} - \text{lower amount})}{\text{original amount}} \times 100 = \text{percent increase} \]

For this question the original amount is 278 and the new amount is 383

\[ \frac{(383 - 278)}{278} = 0.37769 \times 100 = 37.8\% \text{ or } 38\% \]

For those of you not math challenged You can take the absolute value of the original amount - new amount) in the numerator.

**TOP: atmosphere & air pollution**
21. **ANS:** B
   The electrostatic precipitator has magnetically charged strips of metal that collect airborne particles. Electrostatic precipitators can be added to smokestacks to filter the air before it flows out into the surrounding atmosphere. SR/RAR_12Jan11

   TOP: atmosphere & air pollution

22. **ANS:** E
   Under high pressure and temperature conditions in an engine, nitrogen and oxygen atoms react to form nitrogen oxides. Catalytic converters in car exhaust systems break down heavier nitrogen gases, forming nitrogen dioxide (NO\(_2\)) - 300 times more potent than carbon dioxide as a greenhouse gas. NO\(_2\) makes up about 7.2 percent of the gases that cause global warming. Vehicles with catalytic converters produced nearly half of that NO\(_2\).

   Carbon dioxide and Volatile Organic Chemicals are also released through the process of combustion. U.S. Environmental Protection Agency (EPA) originally viewed carbon dioxide as a product of "perfect" combustion, but now views CO\(_2\) as a pollution concern. More VOC’s are actually released when the car is not given proper time to warm up before driving.


   TOP: atmosphere & air pollution

23. **ANS:** B
   Ozone absorbs harmful ultraviolet light before it reaches the surface of the Earth. Without beneficial ozone in the stratosphere, increased amounts of ultraviolet light reach the surface of the Earth and increase the rates of skin cancer. This is especially true for locations that are located near the equator where sunlight is more direct year round.

   The ozone degradation that occurs over Antarctica migrates northward toward Australia, New Zealand and Fiji and reduces stratospheric ozone levels from 3-20% in a given year (p. 521, Miller LITE, 17th Ed.) RAR_12Jan11

   TOP: atmosphere & air pollution

24. **ANS:** B
   A thermal inversion occurs when cooler air is trapped below warmer air in the atmosphere. This often happens in regions that are surrounded on three sides by mountains and open to a large body of water on the fourth. The cooler air being more dense does not disperse but hangs low over a city collecting any air pollutants emitted. The warmer air does not mix because it is less dense and forms a trapping layer above the cooler air.

   TOP: atmosphere & air pollution
25. **ANS: D**

Smog is a chemical mixture of gases that forms a brownish-yellow haze primarily over urban areas. Components of smog include ground-level ozone, nitrogen oxides (NOx), volatile organic compounds (VOC), sulfur dioxide, acidic aerosols and gases, and particulate matter. These gases result from a reaction between certain airborne pollutants and strong sunlight.

http://www.ncf.ca/ip/social.services/eco/info/primer/smog/all

**TOP:** atmosphere & air pollution

26. **ANS: E**

Acid rain actually increases the amounts of metals found in drinking water. As the acid percolates through the soil, it releases copper, lead, and other metals trapped in soils and carries them to the water table where they enter the drinking water.

**TOP:** atmosphere & air pollution

27. **ANS: A**

Nitrogen dioxide emitted from vehicles and factories into the air is brownish when it is highly concentrated. Nitrogen dioxide absorbs ultraviolet light energy from the visible rays of the sun and is photodegraded into nitric oxide (NO) and atomic oxygen (O). The reaction properties of the atomic oxygen generated here are high and it forms ozone by reacting with oxygen (O₂) immediately.

http://www.apec-vc.or.jp/e/modules/tinyd01/index.php?id=25

Sunlight, VOCs and NOₓ all contribute the formation of phytochemical smog (pp. 470-471 Miller LITE, 17th Ed.) RAR_12an11

**TOP:** atmosphere & air pollution

28. **ANS: C**

Global winds carry air pollutants from cities in eastern Asia eastward (prevailing westerlies). These are deposited on the pristine terrain in Alaska.

**TOP:** atmosphere & air pollution

29. **ANS: E**

Since the enactment of the original Clean Air Act in 1970, all of the major air pollutants, except CO₂ (note considered a pollutant at the time) have declined (pp. 485-486, Miller LITE, 17th Ed.) RAR_12Jan11

**TOP:** atmosphere & air pollution

30. **ANS: C**

The enforcement of the Federal Clean Air Act has lead to a 54% decrease in atmospheric VOCs and 31% decrease in atmospheric Small Particulate Matter (SPM) despite a 126% increase in GDP and a 91% increase in vehicle miles traveled by American commuters. Establishing a federal agency like the EPA is not as important and enforcing existing environmental legislation. (pp. 486-487, Miller LITE). RAR 12Jan11.
31. **ANS:** C
Sulfate ions can chemically weather softer building materials such as gypsum dry wall or flooring made of limestone (p. 470, Miller LITE, 17th Ed). SW/RAR_12Jan11.

**TOP:** atmosphere & air pollution

32. **ANS:** A
Small Particulate Matter (PM2.5) poses more potential damage to the lungs because it is harder to remove by ciliary beating and coughing and therefore get deeper into the lungs irritating bronchioles and alveolar membranes. SW/RAR_12Jan11.

**TOP:** atmosphere & air pollution

33. **ANS:** B
Methane concentrations were higher in the earth’s atmosphere prior to the evolution of aerobic respiration. Methane is generated by methanogenic prokaryotes in landfills and wetland. It is also generated by symbiotic bacteria living within a cows’ GI tract. Further it is trapped in the earth’s crust and can be released from oil and natural gas wells. Methane is 20x more effective as a greenhouse gas than carbon dioxide. (p. 471, Miller LITE, 17th Ed.) RAR_12Jan11.

**TOP:** water & land pollution | atmosphere & air pollution

34. **ANS:** A
A decrease in thermal gradients between tropical and subarctic regions could slow the rate ocean currents and decrease the amount of convective currents within the ocean (large areas of the ocean would not mix below the surface). This change in ocean currents could lead to colder arctic areas and exacerbate warming in the tropics. SW/RAR_12Jan11.

**TOP:** biogeochemical cycles & global change | atmosphere & air pollution | atmosphere & air pollution

35. **ANS:** C
The only thing that could cause such a great variation in climate warming for an extended period of time on Earth is the solar activity. However, Scientists from the International Panel on Climate Change (IPCC) uncovered data that suggest that solar activity has decreased since 1975 while tropospheric warming has increased (p. 502, Miller LITE, 17th Ed.). RAR_12Jan11.

**TOP:** atmosphere & air pollution

36. **ANS:** B
The correct interpretation of the graph is that CO₂ concentrations have increased steadily in the Northern Hemisphere since data has been collected at Mauna Loa (c.1958). RAR_12Jan11

**TOP:** atmosphere and air pollution

37. **ANS:** A
Global energy demand has increased during the last 40 years as both developing and developed nations continue to get there energy from fossil fuels (coal in particular). Combustion of coal and other fossil fuels results in an increase in mean atmospheric carbon dioxide levels. These increased levels of CO₂ have not been mitigated by natural process of terrestrial and marine photosynthesis. RAR_12Jan11.

**TOP:** atmosphere and air pollution