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# AP Environmental Science

## Sample Student Responses and Scoring Commentary

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#### **Free Response Question 4**

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# AP<sup>®</sup> ENVIRONMENTAL SCIENCE 2018 SCORING GUIDELINES

## Question 4

In many parts of the world, biomass like peat, wood, and animal waste is burned indoors for cooking and home heating. Combustion of these fuels releases harmful household air pollutants that pose a health threat to billions of people, mostly in less developed countries.

(a) Air pollutants are released during the burning of biomass indoors for cooking and heating.

- (i) **Identify** TWO air pollutants released during the burning of biomass indoors for cooking and heating.

(2 points; 1 point for each correct identification of an air pollutant released during the burning of biomass)

- (ii) **Identify** a specific human respiratory illness that one of the pollutants you identified may cause.

(1 point for correct identification of a specific respiratory illness linked to identified pollutant)

Identification of TWO air pollutants	Identification of a specific human respiratory illness linked to identified pollutant
<ul style="list-style-type: none"> <li>• Carbon monoxide (CO)</li> </ul>	<ul style="list-style-type: none"> <li>• CO poisoning</li> </ul>
<ul style="list-style-type: none"> <li>• Particulate matter (PM)</li> </ul>	<ul style="list-style-type: none"> <li>• Asthma</li> <li>• Chronic obstructive pulmonary disease (COPD)</li> <li>• Emphysema</li> <li>• Bronchitis</li> <li>• Lung cancer</li> </ul>
<ul style="list-style-type: none"> <li>• Nitrogen oxides (NO<sub>x</sub>)</li> </ul>	<ul style="list-style-type: none"> <li>• Pneumonia</li> <li>• Asthma</li> </ul>
<ul style="list-style-type: none"> <li>• Sulfur oxides (SO<sub>x</sub>)</li> </ul>	<ul style="list-style-type: none"> <li>• Bronchitis</li> <li>• Emphysema</li> <li>• Asthma</li> </ul>
<ul style="list-style-type: none"> <li>• Trace metals, such as lead, mercury, arsenic, and cadmium</li> </ul>	<ul style="list-style-type: none"> <li>• Bronchitis</li> </ul>
<ul style="list-style-type: none"> <li>• Methane (CH<sub>4</sub>)</li> </ul>	<ul style="list-style-type: none"> <li>• Bronchitis</li> </ul>
<ul style="list-style-type: none"> <li>• Volatile organic compounds (VOCs)</li> </ul>	<ul style="list-style-type: none"> <li>• Bronchitis</li> <li>• Asthma</li> </ul>

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## Question 4 (continued)

- (b) **Identify** one realistic approach, other than banning the practice of burning biomass indoors, which could be used to reduce the impact of biomass combustion indoors on human respiratory health. **Describe** how this approach could reduce the incidence of respiratory illness.

(2 points; 1 point for correct identification of a realistic approach to reducing the impact and 1 point for correct description of reduction of illness linked to identified approach)

<b>Identify</b> one realistic approach	<b>Describe</b> how this approach would reduce the incidence of respiratory illness
Ventilate through structural change (chimney construction, opening windows and doors)	Removes some or all of the air pollution from indoors/transfers pollutants out of the home, leading to less respiratory illness
Switch to cleaner-burning/more efficient cooking stove	Requires less fuel to be burned releasing fewer air pollutants into the home, leading to less respiratory illness
Switch to a different energy source (solar, natural gas, biogas, electric)	Produces less or no indoor air pollutants, leading to less respiratory illness
Cook outdoors	Move the source of the air pollutant outside/leads to less or no concentrated air pollution inside, leading to less respiratory illness

In 2016 approximately four million people died from illnesses attributed to household air pollutants from burning biomass indoors. More than 10 percent of these deaths occurred in children under the age of five in less developed countries.

- (c) **Discuss** one reason children under the age of five are at a greater risk than adults for illnesses linked to household air pollutants.

(1 point for correct discussion of why children under the age of five are at a greater risk)

- Children have an underdeveloped or less-developed immune systems leading to a greater risk of illness following exposure.
- Children have a lower body mass leading to a higher relative dose of air pollution.
- Children spend more time indoors leading to higher exposure to air pollution.
- Children have smaller respiratory systems (narrow airways) so mild inflammation may cause more severe respiratory distress.

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## Question 4 (continued)

In more developed countries, indoor air pollution is also a problem. Common indoor air pollutants in developed countries include:

- asbestos
- radon
- mold

(d) Choose TWO of the three common indoor air pollutants (asbestos, radon, or mold) listed above and complete the following table.

(i) **Identify** a source for each indoor air pollutant

(2 points; 1 point for correct identification of a source of each indoor air pollutant chosen)

(ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

(2 points; 1 point for correct description of method of reduction for each indoor air pollutant chosen)

	<b>Identification of a source</b>	<b>Description of a method for reducing exposure</b>
Asbestos	<ul style="list-style-type: none"> <li>• Building materials (cement, floor tiles, ceiling panels, drywall, popcorn ceiling)</li> <li>• Insulation</li> <li>• Naturally occurring in soil and rocks in a dirt-floor basement or crawlspace</li> </ul>	<ul style="list-style-type: none"> <li>• Safely remove asbestos-containing materials/abatement</li> <li>• Encapsulate/cover and seal materials/construct temporary enclosure</li> <li>• Leave undisturbed</li> </ul>
Radon	<ul style="list-style-type: none"> <li>• Soil, rocks, Earth's crust</li> <li>• Gas from uranium containing rocks</li> <li>• Gas penetrates foundation</li> </ul>	<ul style="list-style-type: none"> <li>• Seal floors, walls, and joints</li> <li>• Install structural exhaust venting</li> <li>• Install subfloor depressurizing system</li> </ul>
Mold	<ul style="list-style-type: none"> <li>• Water from flooding, natural disasters, or leaks</li> <li>• Poorly vented or maintained damp environments</li> </ul>	<ul style="list-style-type: none"> <li>• Replace or repair damaged surfaces/structures</li> <li>• Clean and/or disinfect affected areas</li> <li>• Dehumidify or ventilate inside air</li> <li>• Improve drainage (from roof or yard, sump pump the basement)</li> </ul>

4. In many parts of the world, biomass like peat, wood, and animal waste is burned indoors for cooking and home heating. Combustion of these fuels releases harmful household air pollutants that pose a health threat to billions of people, mostly in less developed countries.

- (a) Air pollutants are released during the burning of biomass indoors for cooking and heating.
  - (i) **Identify** TWO air pollutants released during the burning of biomass indoors for cooking and heating.
  - (ii) **Identify** a specific human respiratory illness that one of the pollutants you identified may cause.
- (b) **Identify** one realistic approach, other than banning the practice of burning biomass indoors, that could be used to reduce the impact of biomass combustion indoors on human respiratory health. **Describe** how this approach could reduce the incidence of respiratory illness.

In 2016 approximately four million people died from illnesses attributed to household air pollutants from burning biomass indoors. More than 10 percent of these deaths occurred in children under the age of five in less developed countries.

- (c) **Discuss** one reason children under the age of five are at a greater risk than adults for illnesses linked to household air pollutants.

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*The Mitochondria is the power house of the cell*

- (d) Choose TWO of the three common indoor air pollutants (asbestos, radon, mold) listed above and complete the following table.
  - (i) **Identify** a source for each indoor air pollutant.
  - (ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure
radon	radioactive materials decaying in rock surrounding the home	Seal completely the home's basement to stop any infiltration of radon gas from the below.
asbestos	Insulation material that is decades old containing microscopic glass shards	Replace any asbestos producing insulation immediately and safely to avoid mesothelioma.

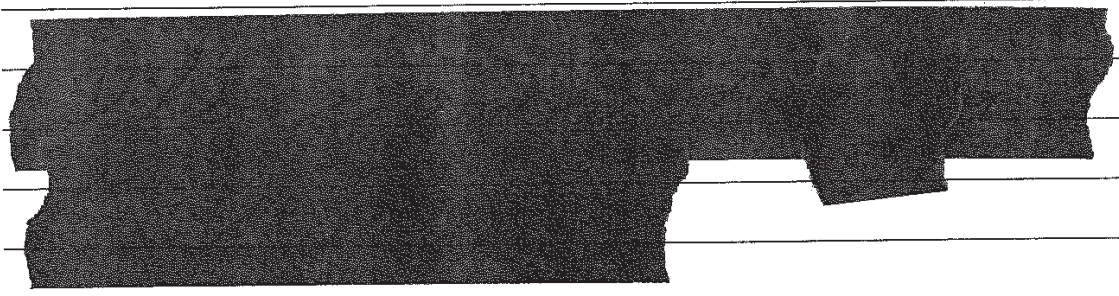
*A:) Two pollutants released during the burning of biomass indoors include carbon monoxide and particulate matter like ash.*

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## ADDITIONAL PAGE FOR ANSWERING QUESTION 4

- a) A person may develop Asthma from continuous exposure to particulate matter like ash.
- b) Proper ventilation techniques like chimneys are necessary. Biomass combustion under a chimney will allow the particulate matter to rise and leave the house.
- c) Children under the age of 5 have smaller masses than adults. This means that it takes less of a dose of an inhaled air pollutant to harm their health than an adult. The concentration of pollutants in a child's body accumulates quicker leading to a greater risk of illness.



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- asbestos
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  - mold
- (d) Choose TWO of the three common indoor air pollutants (asbestos, radon, mold) listed above and complete the following table.
- Identify a source for each indoor air pollutant.
  - Describe a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure
radon	decaying uranium	have proper ventilation, allow air flow, fill cracks in foundation
asbestos	insulation	use other forms of insulation, have proper ventilation

a) i) Carbon dioxide & particulate matter are two air pollutants released during the burning of biomass.

## ADDITIONAL PAGE FOR ANSWERING QUESTION 4

ii) Asthma can be a result of particulate matter making its way into your lungs.

b) Installing a chimney. This allows the byproducts of the combustion to be in one area & be ventilated out instead of trapped in the house & breathed.

c) Children under the age of five are smaller so they will not be able to withstand the dosage an adult would.

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- (i) **Identify** a source for each indoor air pollutant.
  - (ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure
asbestos	common in older buildings and areas like flooring	redo/renovate/cover any contaminated flooring or other building areas
mold	outside contaminants that have optimal growing conditions inside	better circulation of any building/house or completely remove the contaminated area

One air pollutant released during the burning of biomass is particulate matter from the biomass. Another possible air pollutant is carbon dioxide. One respiratory illness that can be

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## ADDITIONAL PAGE FOR ANSWERING QUESTION 4

Caused by particulate matter is emphysema, which is when the particulates inhaled by a person build up in the lungs.

One approach that could be used to reduce the impact of biomass combustion indoors is to develop other sources of renewable energy. For example, photovoltaic cells can be used to obtain solar energy and convert it into useful electrical energy that can be used indoors. This would reduce respiratory illness because the use of cleaner energy like solar energy prevents the burning of biomass, which prevents the release of pollutants like carbon dioxide and particulate matter.

One reason children are at a greater risk for illnesses is because the dose-response relationship measures the effects of toxic air pollutants in mg/kg. Children have a smaller body mass, which means that fewer air pollutants are necessary to cause illness and even death.

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## 2018 SCORING COMMENTARY

### Question 4

#### Overview

The intent of the question was to measure the students' knowledge regarding indoor air pollution and the potential health effects of indoor air pollution. Students were asked to identify two air pollutants associated with burning biomass indoors and a specific illness related to one of the pollutants they identified. Students were then asked to identify a realistic approach that could be used to reduce the impact of burning biomass indoors on human health and to describe how this approach could reduce the incidence of respiratory illness. Additionally, students were asked to discuss why children under the age of five, as compared to adults, are more susceptible to illness that results from indoor air pollution. These concepts were drawn from the following sections of the course description: VI. Pollution, A. Pollution Types, 1. Air pollution and B. Impacts on the Environment and Human Health, 1. Hazards to human health.

Students were also asked to address indoor air pollutants that typically occur in more developed countries. Given a choice of three common indoor air pollutants (asbestos, radon, and mold), students were asked to choose two of the three pollutants and identify a source for each chosen pollutant. Students were also asked to describe a method that could be used to reduce exposure to the two indoor air pollutants they chose. Student responses could have been recorded in the provided table. These concepts were drawn from the following sections of the course description: VI. Pollution, A. Pollution Types, 1. Air Pollution, 3. Water Pollution, and 4. Solid Waste Pollution as well as from VI. Pollution, B. Impacts on the Environment and Human Health, 2. Hazardous chemicals in the environment.

#### Sample: 4A

#### Score: 10

The response earned 3 points in part (a): 2 points in (a)(i) for correctly identifying “carbon monoxide” and “particulate matter” as indoor air pollutants that result from burning biomass and 1 point in (a)(ii) for identifying that particulate matter can cause asthma. The response earned 2 points in part (b): 1 point for identifying that “ventilation techniques like chimneys” can be used to reduce the impact of biomass burning indoors and 1 point for describing that chimneys “allow the particulate matter to rise and leave the house” reducing concentration of particulates in the home. The response earned 1 point in part (c) for discussing that “[c]hildren ... have smaller masses than adults” and “[t]his means it takes less of a dose ... to harm their health.” Four points were earned in part (d). The response earned 2 points in (d)(i): 1 point for identifying a source of radon as “radioactive materials in rock” and 1 point for identifying that old insulation is a source of asbestos. The response earned 2 points in part (d)(ii): 1 point for describing that exposure to radon could be reduced by completely sealing the basement of the house and 1 point for describing that asbestos exposure can be reduced by safely removing the asbestos.

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2018 SCORING COMMENTARY**

**Question 4 (continued)**

**Sample: 4B**

**Score: 8**

The response earned 1 point in part (a)(i) for correctly identifying particulate matter as an indoor air pollutant that results from burning biomass. No point was earned for carbon dioxide because it is not an indoor air pollutant. The response earned 1 point in (a)(ii) for identifying that “[a]sthma can be a result of particulate matter.” Two points were earned in part (b): 1 point for identifying “[i]nstalling a chimney” and 1 point for describing that “[t]his allows the byproducts of combustion to be ... ventilated out instead of trapped in the house & breathed.” The response earned 1 point in part (c) for discussing that “[c]hildren under the age of five are smaller so they will not be able to withstand the dosage an adult would.” Three points were earned in part (d). The response earned 2 points in (d)(i): 1 point for identifying “decaying uranium” as a source of radon and 1 point for identifying insulation as a source of asbestos. One point was earned in (d)(ii) for describing “have proper ventilation, allow air flow” as a method to reduce exposure to radon. “Use other forms of insulation” did not earn a point, as the student does not describe how the current insulation must be safely or professionally removed first to reduce exposure.

**Sample: 4C**

**Score: 6**

The response earned 2 points in part (a): 1 point in (a)(i) for correctly identifying particulate matter as an indoor air pollutant that results from burning biomass and 1 point in (a)(ii) for identifying that particulate matter can cause emphysema. The response earned 2 points in part (b): 1 point for identifying that “photovoltaic cells can be used to obtain solar energy” and 1 point for describing that “the use of cleaner energy like solar energy prevents the burning of biomass, which prevents the release of pollutants like ... particulate matter.” The response earned 1 point in part (c) for stating that “the dose-response relationship” is important and “children have a smaller body mass, which means that fewer air pollutants are necessary to cause illness.” The response earned 1 point in (d)(i) for identifying “older buildings and areas like flooring” as a source of asbestos. No points were earned in (d)(ii) because the responses for the methods to reduce both sources are vague.