AP® ENVIRONMENTAL SCIENCE
2016 SCORING GUIDELINES

Question 2

(a) Use the data below to respond to the following. For each calculation, show all your work.

(i) **Calculate** the weight (in tons) of rock waste produced globally each year when iron ore is converted to pig iron.

(1 point for the correct answer with work shown)

1.6 billion tons of iron ore – 1.2 billion tons of pig iron = 0.4 billion tons of waste

OR

$1.6 \times 10^9 - 1.2 \times 10^9 = 4 \times 10^8$

(ii) **Calculate** the weight (in tons) of pig iron that could be produced if all of the estimated global iron ore reserves were used for pig iron production.

(2 points: 1 point for the correct setup and 1 point for the correct answer)

$\frac{1.2 \text{ billion tons pig iron}}{1.6 \text{ billion tons iron ore}} \times 800 \text{ billion tons iron ore} = 600 \text{ billion tons iron}$

OR

$\frac{1.2}{1.6} = 0.75 \qquad 0.75 \times 800 \text{ billion} = 600 \text{ billion} \qquad \textbf{OR} \qquad \frac{1.2}{1.6} = \frac{x}{800}$

OR

$\frac{1.2 \times 10^9}{1.6 \times 10^9} \times 8.0 \times 10^{11} = 6.0 \times 10^{11}$

(iii) **Calculate** the weight (in tons) of the current global iron ore reserves that would be used to make steel if the current trends continue.

(1 point for the correct answer with work shown)

0.95×800 billion tons of iron = 760 billion tons iron ore used to make steel

OR

$0.95 \times 800 = 760$ billion

OR

$9.5 \times 10^{-1} \times 8 \times 10^{11} = 7.6 \times 10^{11}$

(b) **Calculate** the weight (in tons) of coal that is conserved each year in North America by recycling steel.

(1 point for a correct answer with work shown)

$\frac{0.7 \text{ fewer tons coal used}}{1 \text{ ton steel recycled}} \times 80 \text{ million tons steel recycled} = 56 \text{ million tons coal saved per year in North America}$

OR

$0.7 \times 80 = 56$ million

OR

$7.0 \times 10^{-1} \times 8.0 \times 10^7 = 5.6 \times 10^7$

Question 2 (continued)

(c) **Describe** TWO environmental problems that are associated with abandoned coal mine sites.

(2 points: 1 point for each correct description of an environmental problem. Only the first two descriptions can earn a point.)

- Subsidence/sinkholes as shafts collapse
- Habitat destruction/slow to recover
- Stream/water quality degradation
- Acid mine drainage
- Heavy metal runoff
- Tailings alter landscape and drainage patterns
- Increased soil erosion
- Particulate/dust pollution
- Animals fall in
- Methane release
- Underground fires difficult to extinguish

(d) **Describe** one method that can be used to mitigate one of the problems you identified in part (c).

(1 point for a correct description of a mitigation method for one of the two environmental problems described in part (c))

- Plant trees or other plants to restore cover/reduce erosion
- Fill in/fence off abandoned shafts to stop subsidence or reduce access
- Prevent acid mine drainage and leaching from sites using retaining ponds, berms, other BMPs
- Treat acid mine drainage with limestone
- Return tailings to excavation sites
- Recontour the land
- Place gravel on surface to reduce wind erosion

(e) **Discuss** one reason why surface coal mining is generally less expensive than subsurface mining.

(2 points for correct identification of a reason linked with a discussion of why surface mining is less expensive)

Reason	Economic Discussion
Wages	Fewer workers needed above ground Workers paid less above ground
Healthcare	Workman's compensation Insurance
Safety	Increased likelihood below ground of ○ severe accidents ○ death ○ black lung
Legal costs	Lawsuits from injuries, accidents, rescues

2A1

2. Iron ores are rocks from which metallic iron can be extracted for steel production. This process involves several steps. Iron ore is first mined and then turned into pig iron in a blast furnace, and some rock waste such as silicon dioxide is separated out. In the final step, the pig iron is refined into steel using a process that includes reacting the molten pig iron with oxygen to remove impurities.

(a) Use the data below to respond to the following. For each calculation, show all your work.

Global Iron and Steel Data
1.6 billion tons of iron ore are used yearly to make pig iron.
1.2 billion tons of pig iron are produced each year.
Iron ore reserves are estimated to be 800 billion tons.
95% of iron ore that is mined is used in steel production.

1.6

(i) **Calculate** the weight (in tons) of rock waste produced globally each year when iron ore is converted to pig iron.

(ii) **Calculate** the weight (in tons) of pig iron that could be produced if all of the estimated global iron ore reserves were used for pig iron production.

(iii) **Calculate** the weight (in tons) of the current global iron ore reserves that would be used to make steel if the current trends continue.

Both iron ore and coal are mined for use in the manufacture of steel. It is estimated that for every ton of steel recycled, 1.25 fewer tons of iron ore and 0.7 fewer tons of coal must be mined. About 80 million tons of steel are recycled each year in North America.

(b) **Calculate** the weight (in tons) of coal that is conserved each year in North America by recycling steel.

Before the year 1900, most mining companies abandoned surface and subsurface coal mine sites once the resource was depleted.

(c) **Describe** TWO environmental problems that are associated with abandoned coal mine sites.

(d) **Describe** one method that can be used to mitigate one of the problems you identified in part (c).

(e) **Discuss** one reason why surface coal mining is generally less expensive than subsurface mining.

(a)

(i) 1.6 billion tons ore − 1.2 billion tons pig iron
= 0.4 billion tons waste

(ii) $\frac{1.2 \text{ bt pig iron}}{1.6 \text{ bt ore}} \times 800 \text{ bt ore} = \frac{960}{1.6} = 600$ billion tons pig iron

800 × 12 = 1600 + 8000 = 9600

1.6)960 → 16)9600 → 96 → 00 → 00

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2

(iii) 800 billion tons ore $\times \frac{95}{100} =$ 760 billion tons used in steel production

95 × 8 = 760

(b) ~~80~~ million tons steel rec. $\times \frac{0.7 \text{ fewer tons coal mined}}{1 \text{ ton rec}} =$ ~~56~~

80,000,000 ~~tons steel rec.~~ $\times \frac{0.7 \text{ fewer tons coal mined}}{1 \text{ ton ~~steel~~ rec.}} =$ 56 million fewer tons coal mined

80,000,000 × 0.7 = 56,000,000

(c) Abandoned coal mines can lead to acid drainage into waterways as ground water moves through the mines, (or runoff passes over strip mines) picking up heavy metals like iron, and sulfur, which add H^+ ions to waterways. Abandoned coal mines can also lead to instability within mountians (subsurface) as the caves they leave behind can collapse when disturbed by earthquakes, causing mountians to partially cave in and habitats on the surface of those mountians to be destroyed.

(d) Limestone buffers can be put in place around abandoned mines. The alkalinity of the limestone counteracts the acid in runoff or groundwater contributed by the mine's tailings.

(e) Subsurface mining poses many more health risks to workers than surface mining such as respratory issues from dust, risk of explosion and bodily impairments from working in confined spaces.

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Lawsuits filed by workers against their employers to compensate them for any of these health problems can ~~cause~~ cost coal companies lots of money and make their business less profitable. Surface mining requires fewer employees and involves fewer risks, so fewer lawsuits are filed ~~or~~ and more profit is kept by the company.

2. Iron ores are rocks from which metallic iron can be extracted for steel production. This process involves several steps. Iron ore is first mined and then turned into pig iron in a blast furnace, and some rock waste such as silicon dioxide is separated out. In the final step, the pig iron is refined into steel using a process that includes reacting the molten pig iron with oxygen to remove impurities.

(a) Use the data below to respond to the following. For each calculation, show all your work.

Global Iron and Steel Data
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95% of iron ore that is mined is used in steel production.

(i) **Calculate** the weight (in tons) of rock waste produced globally each year when iron ore is converted to pig iron.

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(iii) **Calculate** the weight (in tons) of the current global iron ore reserves that would be used to make steel if the current trends continue.

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(b) **Calculate** the weight (in tons) of coal that is conserved each year in North America by recycling steel.

Before the year 1900, most mining companies abandoned surface and subsurface coal mine sites once the resource was depleted.

(c) **Describe** TWO environmental problems that are associated with abandoned coal mine sites.

(d) **Describe** one method that can be used to mitigate one of the problems you identified in part (c).

(e) **Discuss** one reason why surface coal mining is generally less expensive than subsurface mining.

a)i) 1.6 billion − 1.2 billion = .4 billion tons of rock waste

ii) 1.2 billion / 1.6 billion × 800 billion = 600 billion tons of pig iron

800 × 1.2 = 960.0

600 × 1.6 = 960.0

736 × 1.6 = 1177.6

300 × 1.6 = 480.0

500 × 1.6 = 800.0

95 × 1.6 = 152.0

950 × 1.6 = 1520.0

73 × 1.6 = 116.8

68 × 1.6 = 108.8

1.6848 × 37 = 62.3376

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2

iii) 800 760.00 billion tons of iron ore
×.95
4000
+72000
760.00

b) 80 million × .7 tons coal / 1 ton = 56.0 million tons of coal

80
×.7
56.0

c) Two environmental problems associated with abandoned coal mines are acid run-off and lack of environmental recovery. Depending on where the mine is located, and what kind of mine it is, it can lead to ~~to~~ acidic runoff which can end up in the surrounding rivers and lakes, ~~prod~~ polluting the water. If a mine is left abandoned, ~~the~~ the environmental effects to the surrounding habitat are not replenished. Each time a mine is created, a habitat is destroyed and if it is abandoned the recovery process will take too long and will continue to harm the environment.

d) One method is a recovery plan. Filling in the mine, replanting trees and replacing what was removed will help to speed the recovery of the environment along promoting healthier surrounding ecosystems. This also helps decrease acid runoff and create new habitats.

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2B3

c) Surface mining is less expensive because instead of drilling into the ground, you are just taking out the whole ecosystem. This means less technology and tools are needed, ~~and you are more likely to~~ and it's much faster. Anything that costs less does more damage to the environment because you are not taking the steps to preserve the ecosystems ~~w~~ affected.

2C

2. Iron ores are rocks from which metallic iron can be extracted for steel production. This process involves several steps. Iron ore is first mined and then turned into pig iron in a blast furnace, and some rock waste such as silicon dioxide is separated out. In the final step, the pig iron is refined into steel using a process that includes reacting the molten pig iron with oxygen to remove impurities.

(a) Use the data below to respond to the following. For each calculation, show all your work.

800
75 · 8 = 568 + 40 = 600
95 · 8 = 720
40
760

Global Iron and Steel Data
1.6 billion tons of iron ore are used yearly to make pig iron.
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Iron ore reserves are estimated to be 800 billion tons.
95% of iron ore that is mined is used in steel production.

(i) **Calculate** the weight (in tons) of rock waste produced globally each year when iron ore is converted to pig iron.

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(b) **Calculate** the weight (in tons) of coal that is conserved each year in North America by recycling steel.

Before the year 1900, most mining companies abandoned surface and subsurface coal mine sites once the resource was depleted.

(c) **Describe** TWO environmental problems that are associated with abandoned coal mine sites.

(d) **Describe** one method that can be used to mitigate one of the problems you identified in part (c).

(e) **Discuss** one reason why surface coal mining is generally less expensive than subsurface mining.

a) (i) 1.6B Tons iron ore − 1.2B tons pig iron = 400M tons of rock waste (SiO_2)

(ii) $800B \text{ tons iron ore} \times \frac{1.2 \text{ Billion tons pig iron}}{1.6 \text{ Billion tons iron ore}} = 600 \text{ Billion tons pig iron}$

(iii) 800B tons iron ore × 95% = 760B tons iron ore used in steel production.

b) 1 ton steel = .7 tons coal 80 Million tons steel · .7 tons coal / 1 ton steel = 56 million tons of coal conserved

2Cb

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

c) • One environmental problem associated with abandoned coal mine sites is the acid mine drainage, which can result in the collapse of mine shafts.

• Another environmental problem associated with abandoned coal mine shafts is the burning of fossil fuels, which makes it possibly toxic to the environment.

d) • Acid mine drainage can be mitigated with a switch to renewable, sustainable energy sources.

e) Surface coal mining is generally cheaper than subsurface mining because subsurface mining is likely to lead to health defects not associated with surface mining. Thus, companies do not have to pay for health services. In addition, it is far less dangerous than subsurface mining.

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2016 SCORING COMMENTARY

Question 2

Overview

The intent of this question overall was to have students evaluate several different items associated with the production of iron, steel, and coal. A set of data was presented, and a narrative asked for students to answer different questions associated with the production of iron and steel.

In parts (a) and (b) students needed to understand mass conservation, and to be able to select the correct information for calculations of iron production, resource depletion, and the impact of recycling on the use of raw resources. In parts (c) and (d) students were asked to consider and describe environmental problems and solutions associated with coal mines. Part (e) required students to discuss why surface coal mining is less expensive than subsurface mining.

Sample Identifier: 2A
Score: 10

One point was earned in part (a)(i) for a correct setup with work shown. Two points were earned in part (a)(ii): 1 point for the correct setup and 1 point for the correct answer. One point was earned in part (a)(iii) for a correct setup with work shown. One point was earned in part (b) for a correct setup with work shown. Two points were earned in part (c): 1 point for a correct description of an environmental problem ("acid drainage into waterways") and 1 point for a correct description of a second environmental problem ("caves … can collapse"). One point was earned in part (d) for the correct discussion of mitigation of problem from part (c) ("limestone buffers … counteracts the acid"). Two points were earned in part (e) for a correct reason and a correctly linked discussion ("health risks to workers … Lawsuits filed").

Sample Identifier: 2B
Score: 8

One point was earned in part (a)(i) for the correct answer with work shown. Two points were earned in part (a)(ii): 1 point for the correct setup and 1 point for the correct answer. One point was earned in part (a)(iii) for the correct answer with work shown. One point was earned in part (b) for a correct setup with work shown. Two points were earned in (c): 1 point was earned for a correct description of an environmental problem ("acid runoff ... polluting the water"), and 1 point was earned for a second correct description of an environmental problem ("a habitat is destroyed"). One point was earned in part (d) for the correct discussion of mitigation of problem ("filling in the mine") from part (c). No points were earned in part (e) as no correct reason and no correctly linked discussion is present.

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Question 2 (continued)

Sample: 2C
Score: 6

One point was earned in part (a)(i) for the correct answer with work shown. Two points were earned in part (a)(ii): 1 point was earned for the correct setup and 1 point was earned for the correct answer. One point was earned in part (a)(iii) for a correct setup with work shown. One point was earned in part (b) for a correct setup with work shown. One point was earned in part (c) for the first correct description of an environmental problem (acid mine drainage). The second point was not earned as no correct description of a second environmental problem is present. The burning of fossil fuels is a global environmental problem, not a specific environmental problem at mine sites. No point was earned in part (d) as no correct discussion of mitigation of problem from part (c) is present. Coal from the mine sites is used for a variety of purposes (i.e., to produce steel), not just for energy, and this is not a mitigation to correct an existing problem. No points were earned in part (e) as no correct reason and no correctly linked discussion are present. Defects are generally not associated with mining. Although companies may pay less for surface mine workers, stating that they do not pay for health services is incorrect. The final point ("it is far less dangerous") is not relevant since the other points are introduced first.