AP® ENVIRONMENTAL SCIENCE
2015 SCORING GUIDELINES

Question 2

Approximately 30 million mobile devices were sold in 1998 in the United States. The number sold increased to 180 million devices in 2007.

(a) Calculate the percent increase of mobile device sales from 1998 to 2007.

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

$$\frac{(180 \text{ million} - 30 \text{ million})}{30 \text{ million}} \times 100\% = 500\%$$

OR

$$\frac{(180 - 30)}{30} \times 100\% = 500\%$$

(Note: Students must show the calculation in order to receive credit for the correct answer. Math setup must be shown for second point.)

(b) Each mobile device sold in 2007 contained an average of 0.03 gram of gold. **Calculate** the number of grams of gold that were used in the production of the mobile devices sold in 2007.

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

$$1.8 \times 10^8 \text{ devices} \times \frac{3 \times 10^{-2} \text{ grams}}{\text{device}} = 5.4 \times 10^6 \text{ grams or } 5{,}400{,}000 \text{ grams}$$

OR

$$180{,}000{,}000 \text{ devices} \times \frac{0.03 \text{ grams}}{\text{device}} = 5{,}400{,}000 \text{ grams or } 5.4 \times 10^6 \text{ grams}$$

(Note: Students must show the calculation to receive credit for the correct answer. Math setup must be shown for second point. Mass units and correct numbers must be shown for second point.)

(c) Assume that the average mass of each mobile device was 0.1 kilogram. The United States Environmental Protection Agency estimates that about 10 percent of the mobile devices sold in 2007 were recycled. **Calculate** the mass (in kilograms) of the mobile devices sold in 2007 that were <u>not</u> recycled.

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

$$1.8 \times 10^8 \text{ devices} \times \frac{0.1 \text{ kg}}{\text{device}} \times 0.9 = 1.62 \times 10^7 \text{ kg or } 16{,}200{,}000 \text{ kg}$$

OR

$$180{,}000{,}000 \text{ devices} \times \frac{0.1 \text{ kg}}{\text{device}} \times 0.9 = 16{,}200{,}000 \text{ kg or } 1.62 \times 10^7 \text{ kg}$$

OR

$$\left(1.8 \times 10^8 \text{ devices} \times \frac{0.1 \text{ kg}}{\text{device}}\right) - \left(1.8 \times 10^8 \text{ devices} \times \frac{0.1 \text{ kg}}{\text{device}} \times 0.1\right) = 1.62 \times 10^7 \text{ kg or } 16{,}200{,}000 \text{ kg}$$

OR

$$\left(180{,}000{,}000 \text{ devices} \times \frac{0.1 \text{ kg}}{\text{device}}\right) - \left(180{,}000{,}000 \text{ devices} \times \frac{0.1 \text{ kg}}{\text{device}} \times 0.1\right)$$

$$= 16{,}200{,}000 \text{ kg or } 1.62 \times 10^7 \text{ kg}$$

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Question 2 (continued)

(d) Discarded mobile devices become part of the electronic waste stream (e-waste). Mercury is often present in e-waste. **Identify** one negative human health effect, other than death, associated with exposure to mercury.

(1 point earned for identification of a specific health effect associated with mercury. Identification of the specific form of Hg responsible for the health effect is not required)

- Birth defects
- Nervous system damage
- Brain damage
- Learning disabilities
- Mental retardation
- Paralysis
- Attention deficit disorder
- Reproductive system damage
- Low sperm counts
- Kidney damage
- Hearing loss
- Minimata disease
- Mad Hatter's disease
- Seizures
- Visual impairment
- Skin disorders
- Headaches
- Mental illness

(e) Improper disposal of e-waste has harmed human health and caused environmental damage in developing countries.

(i) **State** TWO reasons why large quantities of e-waste from the United States are shipped to developing countries rather than being recycled in the United States.

(2 points: 1 point for each of two reasons why e-waste is shipped to developing countries. Acceptable responses include a variety of potential answers, but the key is to include a reason why the U.S. sends the material, not why the receiving country would want it)

Economic

- Lower labor costs in developing countries
- Disposal is cheaper in developing countries
- Shipment/recycling/disposal in developing countries is cheaper than transporting and landfill tipping fees within the U.S.
- Corruption of officials allows evasion of more expensive recycling and disposal options

(Note: "Cheaper" earns only one point unless two distinct reasons are given.)

Public Relations

- Recycling or disposal inside of the U.S. may be a public relations problem (NIMBY)
- When e-waste is shipped outside of the U.S., companies often avoid internal scrutiny

Regulatory/Liability

- Laws and enforcement may be lax
- Environmental impacts of disposal in the U.S. (pollution) may be more visible long-term
- U.S. workers are more likely to be able to sue successfully over health problems
- "Watchdog" organizations common in U.S. may be less common in developing countries

Question 2 (continued)

(ii) Retailers or manufacturers could take specific steps to dramatically reduce the amount of e-waste. **Describe** a realistic change in current practices that would accomplish this.
(1 point for a realistic change)

- Encourage recycling/reuse (trade-in incentives, rebates, repurchase/buy-back, mail-in)
- Reduce planned obsolescence as a design objective
- Production of modular units that can be reused/refurbished or parts (i.e. power supplies) that can be reused
- Make devices smaller and/or more durable
- Shift toward service flow economy
- Establish cradle-to-grave and/or cradle-to-cradle tracking of manufactured products

2A1

2. Approximately 30 million mobile devices were sold in 1998 in the United States. The number sold increased to 180 million devices in 2007.

   (a) **Calculate** the percent increase of mobile device sales from 1998 to 2007.

   (b) Each mobile device sold in 2007 contained an average of 0.03 gram of gold. **Calculate** the number of grams of gold that were used in the production of the mobile devices sold in 2007.

   (c) Assume that the average mass of each mobile device was 0.1 kilogram. The United States Environmental Protection Agency estimates that about 10 percent of the mobile devices sold in 2007 were recycled. **Calculate** the mass (in kilograms) of the mobile devices sold in 2007 that were not recycled.

   (d) Discarded mobile devices become part of the electronic waste stream (e-waste). Mercury is often present in e-waste. **Identify** one negative human health effect, other than death, associated with exposure to mercury.

   (e) Improper disposal of e-waste has harmed human health and caused environmental damage in developing countries.

      (i) **State** TWO reasons why large quantities of e-waste from the United States are shipped to developing countries rather than being recycled in the United States.

      (ii) Retailers or manufacturers could take specific steps to dramatically reduce the amount of e-waste. **Describe** a realistic change in current practices that would accomplish this.

a. $\left(\frac{180 \text{ million} - 30 \text{ million}}{30 \text{ million}}\right) = (5) \times 100\% = 500\%$ increase

b. $\left(\frac{.03 \text{ g Gold}}{1 \text{ mobile phone}}\right)\left(\frac{180 \times 10^8 \text{ phones}}{}\right) = 5.4 \times 10^6$ grams of gold

c. $100\% - 10\%$ recycled $= 90\%$ not recycled $(180 \times 10^8 \text{ phones})(90\% \text{ not recycled}) =$
$(1.62 \times 10^8 \text{ phones not recycled})\left(\frac{.1 \text{ kg}}{1 \text{ phone}}\right) = 1.62 \times 10^7$ kg not recycled

d. Mercury can accumulate in our food recources. It accumulates in fish which we then eat. This can cause neurological damage because of the high concentrations of a heavy metal.

e. One reason is that it is cheaper to send our e-waste overseas. It is expensive to recycle. Another reason is there is a lot of regulations on handling e-waste

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here but in other developing countries there are not the same regulations so it is just easier to dispose of in those developing countries.
One way to decrease e-waste is to make products that are meant to last. In our consumer society we have phones for not even a year before a new product comes out that makes the older product "obsolete" or at least seem to be. These older phones are just discarded and added to the e-waste.

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      (i) **State** TWO reasons why large quantities of e-waste from the United States are shipped to developing countries rather than being recycled in the United States.

      (ii) Retailers or manufacturers could take specific steps to dramatically reduce the amount of e-waste. **Describe** a realistic change in current practices that would accomplish this.

a) $\frac{f-i}{i} \times 100 = \%\ i$ $\quad \frac{180\times10^6 - 30\times10^6}{30\times10^6} \times 100 \quad \frac{60\times10^6}{30\times10^6} \times 100 = 2\times100 = 200\%$

B) # of devices × # of grams $\quad 180\times10^6 \times 0.03\,g \quad 180\times10^6 \times 3\,g =$ 5400000 g of gold.

C) # of devices × weight = $\quad 180\times10^6 \times 0.1$ kilogram $\quad 180\times10^5 \times 1\,kg =$ 18000000 kilograms $\quad 18,000,000 \times 9 =$ non recycled phones mass $1,800,000 \times 9 = 16200000$ kilograms

D) Mercury is a teratogen and can cause birth defects

e(ii) It is a cheaper and much easier way of dealing with the issue

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(b) Phone companies could offer rebates or benefits for customers that return their old phones to be recycled

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a) $\frac{|30-180|}{30} = \frac{150}{30} = 5 \times 100 = 500\%$ inc from 1998–2007

b) $180\,000\,000 \times 0.03 = 5,400,000$ grams of gold

c) $180\,000\,000 \times 0.9 = 162,000,000$ kilograms

d) Mercury from e-waste can cause neurological damage to those exposed which results in memory loss.

2 C2

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

e) i) E-waste is shipped to developing countries because the US pays other countries to deal with extra e-waste. Also the US may have heavier restrictions on storing e-waste in land fills than some developing countries, thus saving US companies money concerning waste disposal.

ii) Manufacturers could create products that are easily upgradable and long lasting, so products don't need to be as often manufactured.

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AP® ENVIRONMENTAL SCIENCE
2015 SCORING COMMENTARY

Question 2

Overview

The question was intended to determine whether students could use the given information about mobile device sales over time, along with device composition and recycling rates to work through a series of calculations. They were asked to determine growth rates, the mass of gold, and the amount of e-waste produced. The three parts increased in complexity. The next part of the question asked for the student to identify a negative human health effect of mercury. The final part of the question asked students to state two reasons why e-waste is often shipped from the U.S. to other countries for recycling and disposal, and how retailers or manufacturers might offer realistic programs to reduce e-waste.

Sample: 2A
Score: 10

Two points were earned in part (a): 1 point for correct setup (the response showed a complete setup and calculation with units and multiplied by 100 percent), and 1 point for the correct answer. This response was an ideal combination of setup and calculation resulting in a correct answer. Two points were earned in part (b): 1 point for correct setup (the response showed a complete setup and calculation with units of grams and phones), and 1 point for the correct answer. Again, this response was an ideal combination of setup and calculation resulting in a correct answer. Two points were earned in part (c): 1 point for correct setup (the response showed a complete sequential setup and calculation — one result fed into an additional setup and calculation — and with units of kg and phones), and 1 point for the correct answer. Again, this response was an ideal combination of setup and calculation resulting in a correct answer. One point was earned in part (d) for identifying "neurological damage" as a correct human health effect from mercury exposure. The source of exposure identified, namely that mercury can accumulate in fish and then be consumed, is also correct but not required. Two points were earned in part (e)(i): 1 point in part (e)(i) for stating "it is a cheaper" alternative as a reason for shipping waste to developing counties from the U.S. (the response further states that recycling would be expensive, which reinforces the cheaper statement, but is not required), and 1 point in part (e)(i) for "a lot of regulation on handling e-waste here" as a reason for shipping waste to developing counties from the U.S. The response further states that "in other developing countries there are not the same regulations so it is just easier to dispose," which supports the differences between the U.S. and the developing country that the e-waste would be shipped to. One point was earned in part (e)(ii) for describing making more durable products as a realistic change reducing the amount of e-waste. The issue of planned obsolescence is introduced after this correct answer, and this does strengthen the earlier description but is not required to earn credit for the answer.

Sample: 2B
Score: 8

One point was earned in part (a) for correct setup. The calculation and answer given in part (a) are not correct, so the second point was not earned. Two points were earned in part (b): 1 point for correct mathematical setup of the equation including the correct use of units of grams and 1 point for calculating a correct answer. Two points were earned in part (c): 1 point for correct mathematical setup of the equation including the correct use of units of kg and 1 point for calculating a correct answer. The calculation was displayed sequentially rather than as a single formula, but that was acceptable. One point was earned in part (d) for identifying "birth defects" as a human health effect from mercury exposure. Initial use of the term "teratogen" is related to developing "birth defects" as the human health effect, so it was considered as part of the correct answer rather than as an initial incorrect answer. If used alone, it would not be considered a human health effect and would not have earned credit. One point was earned in part (e)(i) for stating it is "cheaper" as a reason for shipping waste to developing counties from the U.S.

Question 2 (continued)

The second reason, "much easier" for shipping waste from the U.S. to a less-developed country, was not correct, so no point was earned. One point was earned in part (e)(ii) for describing offering rebates and recycling of the old phones as a realistic change reducing the amount of e-waste.

Sample: 2C
Score: 6

Two points were earned in part (a): 1 point for correct setup and 1 point for correct calculation and answer. Note the use of absolute value in calculating the denominator, which is an acceptable mathematical way of calculating a difference. One point was earned in part (b) for correct answer with calculation. The setup included all numerical parts but did not include mass units, so the second point was not earned. No points were earned in part (c). The setup was incomplete, as it did not include the mass of each mobile device and thus also resulted in the wrong answer. One point was earned in part (d) for identifying "neurological damage" as a human health effect from mercury exposure. The addition of "memory loss" was related but not required. One point earned in part (e)(i) for stating that "the U.S. may have heavier restrictions on storing e-waste in landfills than some developing countries" as a reason for shipping waste to developing countries from the U.S. The response did not earn a second point by stating that these restrictions were "saving U.S. companies money" as this discussion directly related to U.S. having greater restrictions than developing countries, so is not considered as a statement of a separate second reason. One point was earned in part (e)(ii) for describing upgradable and longer lasting products as a realistic change reducing the amount of e-waste by not requiring the additional manufacturing in the first place.