

2013 AP[®] ENVIRONMENTAL SCIENCE FREE-RESPONSE QUESTIONS

2. Battery electric vehicles (BEVs) have been introduced to consumers as an alternative way to reduce the environmental effects caused by use of internal-combustion engine (ICE) vehicles. A comparison of both vehicle types can help determine whether the use of BEVs would be beneficial in the future. Where calculations are required, show your work.
- (a) **Identify** THREE strategies that the federal government could implement to encourage the use of BEVs.
 - (b) Assume that the fuel efficiency of the ICE vehicle is 25 miles per gallon (mpg) and that gasoline costs \$3.75 per gallon (gal). **Calculate** the cost of gasoline per mile.
 - (c) The charger supplies energy to the BEV battery at an average rate of 4.0 kilowatts (kW) and fully charges the BEV battery in 7.0 hours. The car will run for 100 miles on a full charge. The cost of electricity is \$0.11 per kilowatt-hour (kWh).
 - i. **Calculate** the cost of the electricity to fully charge the battery. Assume that the battery is not charged to begin with.
 - ii. **Calculate** the cost of electricity per mile to drive the BEV.
- When it is driven 100 miles, the ICE vehicle contributes 72.8 pounds (lb) of CO₂ from the burning of the gasoline. The drilling, refining, and transportation costs of getting the gasoline to the gas station add an additional 17.7 lb of CO₂ per 100 miles. The BEV does not emit any CO₂ itself, but the extraction, transportation, and combustion of the coal that produced the electricity at the power plant add 63.6 lb of CO₂ for the same 100 miles.
- (d) **Calculate** the difference in the amount of CO₂ that would enter the atmosphere if both cars were driven 100 miles.
 - (e) **Describe** TWO economic impacts (excluding costs related to climate change resulting from CO₂ emissions or the cost of gasoline at the pump) that result from an increased number of BEVs on the road.

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Question 2

(a) **Identify THREE strategies that the federal government could implement to encourage the use of battery electric vehicles (BEVs).**

(3 points: 1 point for each strategy; examples of acceptable strategies are shown)

The federal government could:

- Increase subsidies for BEV industry **OR** decrease subsidies for ICE industry
- Increase tax on carbon/gasoline/diesel fuel
- Offer tax incentives or rebates for purchasing BEVs **OR** institute a tax on the purchase of ICE vehicles
- Increase subsidies for power companies **OR** decrease subsidies for petroleum industry
- Run educational campaigns/commercials/PSAs supporting BEVs
- Allow BEVs to use HOV/carpool lanes or provide funds for BEV lanes
- Replace federal ICE vehicles with BEVs
- Restrict ICE vehicles (e.g., prohibit use of ICE vehicles in urban areas or at certain times)
- Make charging stations more accessible
- Adopt stricter federal standards for tailpipe emissions or gas mileage (e.g., CAFE)
- Offer tax incentives for purchasing home charging stations
- Offer financial incentives for trading in an ICE vehicle for a BEV

(b) **Assume that the fuel efficiency of the ICE vehicle is 25 miles per gallon (mpg) and that gasoline costs \$3.75 per gallon (gal). Calculate the cost of gasoline per mile.**

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

$$\frac{\$3.75}{\text{gal}} \times \frac{\text{gal}}{25 \text{ miles}} = \$0.15 \text{ [per mile]} \quad \text{OR} \quad \frac{\$3.75}{25 \text{ miles}} = \$0.15 \text{ [per mile]}$$

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Question 2 (continued)

- (c) The charger supplies energy to the BEV battery at an average rate of 4.0 kilowatts (kW) and fully charges the BEV battery in 7.0 hours. The car will run for 100 miles on a full charge. The cost of electricity is \$0.11 per kilowatt-hour (kWh).**

- (i) Calculate the cost of the electricity to fully charge the battery. Assume that the battery is not charged to begin with.**

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

$$7.0 \text{ hours} \times 4.0 \text{ kW} \times \frac{\$0.11}{\text{kWh}} = \$3.08^*$$

*\$3.10 also earns a point.

- (ii) Calculate the cost of electricity per mile to drive the BEV.**

(1 point can be earned for the correct answer, with or without work shown; wrong answer from (c)(i), used correctly, can still earn a point)

$$\frac{\$3.08}{100 \text{ miles}} = \$0.03 \text{ [per mile]}$$

- (d) Calculate the difference in the amount of CO₂ that would enter the atmosphere if both cars were driven 100 miles.**

(1 point can be earned for the correct answer with work shown; first equation is optional)

$$\begin{aligned} 72.8 + 17.7 &= 90.5 \text{ lb} \\ 90.5 - 63.6 &= 26.9 \text{ lb} \end{aligned}$$

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Question 2 (continued)

- (e) Describe **TWO** economic impacts (excluding costs related to climate change resulting from CO₂ emissions or the cost of gasoline at the pump) that result from an increased number of BEVs on the road.

(2 points: 1 point for each correct impact; only 1 point is allowed per row in table)

Impacts from Increased Use of BEVs Include:	Impacts from Decreased Use of ICE Vehicles Include:
Increase in jobs/profit in electrical industry (e.g., power plants, charging stations)	Decrease in jobs/profit in gasoline/petroleum industry (e.g., gas stations)
Increase in expenditures for production of electricity (e.g., exploration, coal mining, building wind farms) or for transport of coal/transmission of electricity	Decrease in expenditures for the production or transport of petroleum (e.g., exploration, drilling, refining)
OR	OR
Increase in revenue in industries related to the production of electricity (e.g., coal mines, wind turbine producers)	Decrease in revenue in industries related to the production or transport of petroleum (e.g., exploration, drilling, refining)
Increase in jobs/profit for manufacturing and repair of BEVs	Decrease in jobs/profit for manufacturing and repair of ICE vehicles
Increase or decrease in cost of BEVs with appropriate supporting explanation (e.g., economies of scale, law of supply and demand)	Increase or decrease in cost of ICE vehicles with appropriate supporting explanation (e.g., economies of scale, law of supply and demand)
Increase in expenditures associated with controlling smokestack emissions (e.g., SO ₂) from power stations	Decrease in expenditures for cleanup of oil spills or gasoline leaks
Increase in price of electricity or fuel used to generate electricity because of increased demand	Decrease in revenue from gas tax
OR	
Increase in household expenditures for electricity	
BEV drivers save money that can be spent elsewhere	
Expenses required for installing charging stations or converting gas stations	
Decrease in expenditures for health care associated with exposure to air pollution (e.g., photochemical smog, gasoline vapors)	
Increase in expenses for/sales of batteries or for battery disposal	