

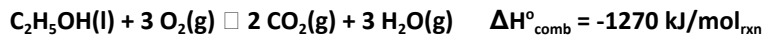


Name: _____ Period: _____
13.2 AP Practice Problem (AP Topics 1.1, 3.1, 3.2, 3.4, 4.7, 6.4, 6.6, & 7.9)

Assigned on Friday, April 10, 2026

Due Monday, April 13, 2026

For parts of the free-response question that require calculations, clearly show the method used and the steps involved in arriving at your answers. You must show your work to receive credit for your answer. Examples and equations may be included in your answers where appropriate.



Ethanol, $\text{C}_2\text{H}_5\text{OH}$, will combust in air according to the equation above.

A. Is O_2 oxidized in the reaction, or is it reduced? Justify your answer in terms of oxidation numbers.

B. When a sample of $\text{C}_2\text{H}_5\text{OH}$ was combusted, the volume of $\text{CO}_2(\text{g})$ produced was 18.0 L when measured at 21.7°C and 1.03 atm. Determine the number of moles of $\text{CO}_2(\text{g})$ that was produced.

C. Determine the volume of $\text{C}_2\text{H}_5\text{OH}(\text{l})$, in mL, that was combusted to produce the volume of $\text{CO}_2(\text{g})$ collected in part B. (The density of $\text{C}_2\text{H}_5\text{OH}(\text{l})$ is 0.79 g/mL.)

D. Determine the amount of heat, in kJ, that is released by the combustion reaction.

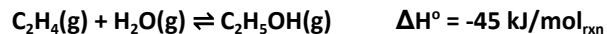
The combustion reaction occurred in a closed room containing 5.56×10^4 g of air originally at 21.7°C . Assume that all of the heat produced by the reaction was absorbed by the air (specific heat = $1.0005 \text{ J}/(\text{g}^\circ\text{C})$) in the room.

E. Determine the final temperature of the air in the room after the combustion.

F. The boiling points of ethanol and dimethyl ether are provided in the following table. Identify the intermolecular force that is most responsible for the difference in boiling point. In terms of this force, explain why the boiling point of ethanol is higher than that of dimethyl ether.

Compound	Structural Formula	Boiling Point ($^\circ\text{C}$)
Ethanol	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$	78
Dimethyl ether	$\begin{array}{c} \text{H} \quad \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{O}-\text{C}-\text{H} \\ \quad \quad \\ \text{H} \quad \quad \text{H} \end{array}$	-24

One method of producing ethanol is by the reaction of ethene and water, as represented below.



G. A chemist wants to run the reaction and maximize the amount of $\text{C}_2\text{H}_5\text{OH}(\text{g})$ produced. Identify two ways the chemist could change the reaction conditions (other than adding or removing any chemical species) to favor the formation of more product. Justify your answer.

Answers:

Part A: 1 pt

The response meets the following criteria.

- The response indicates that O_2 is reduced.
- The response indicates that the oxidation number of oxygen changes from zero in O_2 to -2 in CO_2 and H_2O .

Part B: 1 pt

The response gives a calculation equivalent to the following.

$$n = \frac{PV}{RT} = \frac{(1.03 \text{ atm})(18.0 \text{ L})}{(0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1})(273.15+21.7 \text{ K})} = 0.766 \text{ mol CO}_2$$

Part C: 2 pts

The response meets both of the following criteria.

- The response indicates that 1 mol of C_2H_5OH produces 2 mol of CO_2 .
- The response gives a calculation equivalent to the following.

$$0.766 \text{ mol CO}_2 \times \frac{1 \text{ mol C}_2\text{H}_5\text{OH}}{2 \text{ mol CO}_2} \times \frac{46.07 \text{ g C}_2\text{H}_5\text{OH}}{1 \text{ mol C}_2\text{H}_5\text{OH}} \times \frac{1 \text{ mL}}{0.79 \text{ g}} = 22 \text{ mL}$$

Part D: 1 pt

The response gives a calculation equivalent to the following.

$$q = n \Delta H_{comb}^{\circ}$$

$$q = 0.766 \text{ mol CO}_2 \times \frac{1 \text{ mol}_{rxn}}{2 \text{ mol CO}_2} \times \frac{-1270 \text{ kJ}}{1 \text{ mol}_{rxn}} = -486 \text{ kJ}$$

The amount of heat released is 486 kJ.

Part E: 1 pt

The response gives a calculation equivalent to the following.

$$q_{air} = -q_{rxn} = +486 \text{ kJ} = +486,000 \text{ J}$$

$$q = mc\Delta T \Rightarrow \Delta T = \frac{q}{mc} = \frac{486,000 \text{ J}}{(5.56 \times 10^4 \text{ g})(1.005 \text{ J/(g } ^\circ\text{C)})} = 8.70^\circ\text{C}$$

$$T_{final} = 21.7^\circ\text{C} + 8.70^\circ\text{C} = 30.4^\circ\text{C}$$

Part F: 2 pts

The response meets both of the following criteria.

- The response indicates that hydrogen bonding is the intermolecular force most responsible for the difference in boiling point.
- The response links the greater strength of the intermolecular forces to a higher boiling point (e.g., by stating that ethanol can form hydrogen bonds between its molecules, whereas dimethyl ether cannot, and that the attractions between molecules are stronger in ethanol than in dimethyl ether and therefore the boiling point of ethanol is higher).

Part G: 2 pts

The response meets both of the following criteria.

- The response indicates that the chemist could decrease the volume of the reaction container, and that this would work because there are fewer moles of gaseous product than moles of gaseous reactants; therefore, an increase in pressure due to a decrease in volume would favor the formation of product.
- The response indicates that the chemist could lower the temperature, and that this would work because a lower temperature favors an exothermic reaction, leading to the conversion of reactants into product.