AP® Chemistry
2002 Sample Student Responses

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3A

3. Consider the hydrocarbon pentane, C_5H_{12} (molar mass 72.15 g).

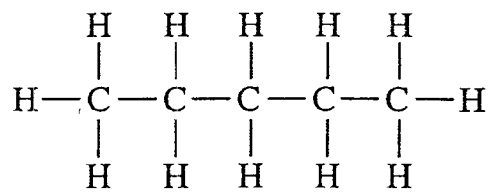
(a) Write the balanced equation for the combustion of pentane to yield carbon dioxide and water.

(b) What volume of dry carbon dioxide, measured at 25°C and 785 mm Hg, will result from the complete combustion of 2.50 g of pentane?

(c) The complete combustion of 5.00 g of pentane releases 243 kJ of heat. On the basis of this information, calculate the value of ΔH for the complete combustion of one mole of pentane.

(d) Under identical conditions, a sample of an unknown gas effuses into a vacuum at twice the rate that a sample of pentane gas effuses. Calculate the molar mass of the unknown gas.

(e) The structural formula of one isomer of pentane is shown below. Draw the structural formulas for the other two isomers of pentane. Be sure to include all atoms of hydrogen and carbon in your structures.



(a) $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$

(b) $2.50\text{g } C_5H_{12} \times \frac{1\text{mol } C_5H_{12}}{72.15\text{g}} \times \frac{5\text{mol } CO_2}{1\text{mol } C_5H_{12}} = .173\text{mol } CO_2$

$785\text{ mm Hg} \times \frac{1\text{ atm}}{760\text{ mm Hg}} = 1.033\text{ atm}$

$PV = nRT$

$V = \frac{(.173\text{mol})(.0821)(298\text{K})}{1.03\text{ atm}} = 4.10\text{L } CO_2$

(c) releases heat → exothermic reaction so ΔH must be negative

$5.00\text{g } C_5H_{12} \times \frac{1\text{mol}}{72.15\text{g}} = .0693\text{ mol } C_5H_{12}$

$\frac{243\text{ kJ}}{.0693\text{mol}} = \frac{x\text{ kJ}}{1\text{mol}}$

$x = 3506.49\text{ kJ}$

$\Delta H = -3.51 \times 10^3\text{ kJ}$

ADDITIONAL PAGE FOR ANSWERING QUESTION 3.

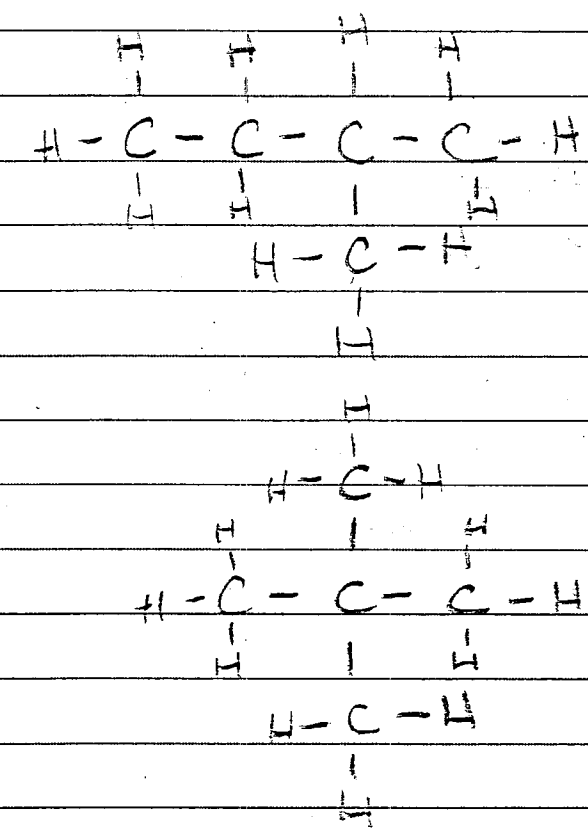
d) $\sqrt{\frac{M_2}{M_1}} = \frac{r_1}{r_2}$ r_1 = pentane, r_2 = unknown

$\sqrt{\frac{M_2}{M_1}} = \frac{r_1}{2r_1} = \frac{1}{2}$

$\frac{M_2}{72.15g} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$

$M_2 = \frac{72.15g}{4} = 18.04g$

e)



3B

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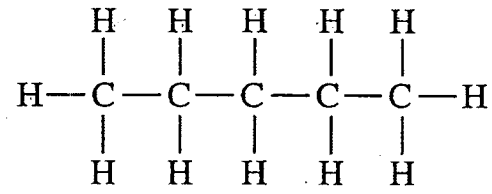


(a) $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$

C = 5×12 = 60
H = 12×1 = 12
72

(b) $2.50\,g\,C_5H_{12} \left|\frac{1\,mol\,C_5H_{12}}{72\,g\,C_5H_{12}}\right| \frac{5\,mol\,CO_2}{1\,mol\,C_5H_{12}} = .174\,mol\,CO_2$

$PV = nRT$

$\frac{PV}{P} = \frac{nRT}{P}$

$785\,mmHg \left|\frac{1\,atm}{760\,mmHg}\right. = 1.03\,atm$

$V = \frac{nRT}{P} \quad V = \frac{(.174\,mol)(.08201)(298)}{1.03} = \boxed{4.13\,L\,CO_2}$

(c) $\frac{-243\,KJ}{5\,g\,C_5H_{12}} \left|\frac{72.15\,g\,C_5H_{12}}{1\,mol}\right. = \boxed{-3506\,KJ/mol = \Delta H}$

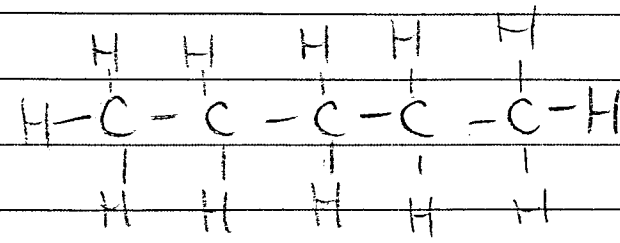
(d) $\frac{2}{1} = \frac{\sqrt{72.15}}{\sqrt{M_1}}$

$\frac{\sqrt{72.15}}{2} = \frac{2\sqrt{M_1}}{2}$

$(4.25)^2 = (\sqrt{M_1})^2$

$\boxed{18.04\,g/mol = M_1 \text{ unknown gas}}$

(e)



3C1

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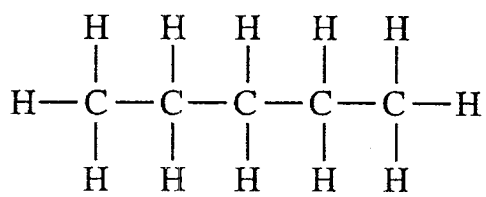

A) $1\ C_5H_{12(g)} + 8\ O_{2(g)} \rightarrow 5\ CO_{2(g)} + 6\ H_2O_{(l)}$

$C_5H_{12}(g) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l)$

B) $PV = nRT$ $\quad 2.50\ g\ C_5H_{12} \left| \frac{1\ mol\ C_5H_{12}}{72.15\ g\ C_5H_{12}} \right. = .035\ mol$

$(1.03\ atm)(V) = (3.5 \times 10^{-2}\ mol)\left(.0821\ \frac{L \cdot atm}{mol\ K}\right)(298K)$

$V = .83\ L$ $\quad 830\ mL$

C) $5.00\ g\ C_5H_{12} \left| \frac{1\ mol\ C_5H_{12}}{72.15\ g\ C_5H_{12}} \right. = .069\ mol$

$1\ mol \left| \frac{243\ kJ}{.069\ mol} \right. = 3521\ kJ$

GO ON TO THE NEXT PAGE.

3C2

ADDITIONAL PAGE FOR ANSWERING QUESTION 3.

D) 72.15 g C_5H_{12} x 2 = 144.3 g MM UNKNOWN

E)