PS 4 Key

① $CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$ $\Delta H_{rxn}^{\circ} = ??$

flipped rxn 1 and ÷2 → $CO(g) \rightarrow C(s) + \frac{1}{2}O_2(g)$ $\Delta H^{\circ} = \frac{-(-221.0\,kJ)}{2} = +110.5\,kJ$

÷2 for rxn 2 → $\underline{C(s) + \frac{1}{2}O_2(g) + 2H_2(g) \rightarrow CH_3OH(g)}$ $\Delta H^{\circ} = \frac{-402.4}{2} = -201.2\,kJ$

$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$

$\Delta H^{\circ}_{rxn} = +110.5\,kJ + (-201.2\,kJ) = \underline{-90.7\,kJ}$

for forming 1 mole $CH_3OH(g)$

$100.0\,g\,CH_3OH\left(\frac{1\,mol}{32.042\,g}\right) = 3.1209\,mol\,CH_3OH$

$3.1209\,mol\left(\frac{-90.7\,kJ}{1\,mol}\right) = \boxed{-283.1\,kJ \text{ released}}$

②

a. $CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$

b. $\Delta H^{\circ}_{rxn} = \Sigma[n\Delta H_f^{\circ}(prod.)] - \Sigma[n\Delta H_f^{\circ}(react.)]$

$\Delta H^{\circ}_{rxn} = [(2\,mol)(-393.5\,\frac{kJ}{mol}) + (3\,mol)(-241.8\,\frac{kJ}{mol})] - [(1\,mol)(-277.7\,kJ/mol) + 0]$

$\Delta H^{\circ}_{rxn} = -1512.4\,kJ - (-277.7\,kJ)$

$\boxed{\Delta H^{\circ}_{rxn} = -1234.7\,kJ}$

$\Delta H^{\circ} < 0 \rightarrow$ Exothermic

Subst.	kJ/mol ΔH_f°
$CO_2(g)$	-393.5
$H_2O(g)$	-241.8
$O_2(g)$	0
$CH_3CH_2OH(l)$	-277.7

③ a. $q_{soda} = mC_s\Delta T$ $\quad m = (1.0\ g/mL)(350\ mL) = 350\ g$

$q_{soda} = (350g)(4.184\ J/g°C)(37.0 - 5.0°C)$ $\quad T_i = 5.0°C$; $T_f = 37.0°C$

$q_{soda} = +46861\ J$ $\quad C_s = 4.184\ J/g\ °C$

$q_{body} = -q_{soda} \rightarrow q_{body} = -46861\ J$

$\boxed{q_{body} = -47\ kJ \text{ of energy expended}}$

b. Add energy inputs and outputs with appropriate signs to find the overall heat input or output to the body.

$q_{in} = +1\ Cal = +4184\ J$

$q_{out} = -46861\ J$ [from (a)]

$q_{total} = 4184\ J + (-46861\ J) = -42677\ J$

= -10.2 Cal output

$\boxed{= -43\ kJ \text{ net output of energy}}$

④ Refer to molar heat capacities, Table 9.3, p. ~~375~~ 385

Substance	C_m (J/mol °C)	
* Al(s)	24.2	* Highest T_f
Pb(s)	26.7	
Air (g)	29.1	
$H_2O(l)$	75.3	

Heat capacity is a measure of how much heat it takes to raise the temp. of a substance by 1 °C. Since Al(s) has the lowest heat capacity, its temperature will increase the most. You can also rationalize this from the equation $q = nC_m\Delta T \longrightarrow \Delta T = \frac{q}{nC_m}$

For the same q and n, the substance with the smallest C_m will have the greatest change in temp.

⑤ $-q_{Cu} = +q_{H_2O}$

$$-[m_{Cu}C_{s,Cu}(T_f - T_{i,Cu})] = +[m_{H_2O}C_{s,H_2O}(T_f - T_{i,H_2O})]$$

$$-[(192g)(0.385 J/g°C)(T_f - 100°C)] = +[(751g)(4.184 J/g°C)(T_f - 4.0°C)]$$

$$-73.92 T_f + 7392 = 3142.184 T_f - 12568.7$$

$$19961 = 3216.1 T_f$$

$$\boxed{6.2°C = T_f}$$

⑥ a. $q_{rxn} = -q_{soln}$

$q_{rxn} = -[m_{soln} C_{s,soln} \Delta T_{soln}]$ $m_{soln} = 106.5 g$

$$q_{rxn} = -[(106.5 g)(4.184 J/g°C)(37.8°C - 21.6°C)]$$

$$q_{rxn} = -7219 J\left(\frac{1 kJ}{1000 J}\right) = \boxed{-7.22 kJ}$$

Heat released.

b. $\Delta H_{rxn} = q_{rxn}$ @ const. P

$\Delta H_{rxn} = -7.22 kJ$ for 6.50g of NaOH reacted.

Find ΔH in $\frac{kJ}{mol\ NaOH}$

$$6.50g\left(\frac{1\ mol\ NaOH}{40.00\ g}\right) = 0.1625\ mol\ NaOH$$

$$\frac{-7.22\ kJ}{0.1625\ mol} = \boxed{-44.4\ \frac{kJ}{mol\ NaOH}}$$