

Constants and conversion factors that you *may* need

$$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$R = 8.21 \times 10^{-2} \text{ L atm K}^{-1} \text{ mol}^{-1}$$

$$R = 62.364 \text{ L Torr K}^{-1} \text{ mol}^{-1}$$

$$1 \text{ atm} = 101.325 \times 10^3 \text{ Pa}$$

$$k = 1.381 \times 10^{-23} \text{ J K}^{-1}$$

$$1 \text{ L} = 10^{-3} \text{ m}^3$$

NOTE: You must show your work to receive credit!

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1) A sample consisting of 1.00 mol of Ar is expanded isothermally at 0°C from 22.8 L to 44.8 L. $C_{p,m}$ for Ar is $20.8 \text{ J K}^{-1} \text{ mol}^{-1}$. Assume ideal gas behavior. Calculate q , w , ΔU , and ΔH for the following processes:

a) reversible expansion

b) expansion against a constant pressure equal to the final pressure in part a).

c) expansion into a vacuum

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2a) If 3.0539 g of liquid ethanol, $\text{C}_2\text{H}_5\text{OH}(\text{l})$ is burned completely at 298.15 K in a bomb calorimeter, the heat evolved is 90.447 kJ.

i) Calculate the molar enthalpy of combustion for ethanol at 298.15 K.

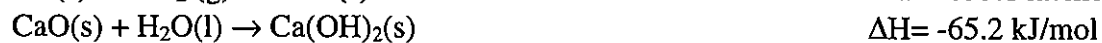
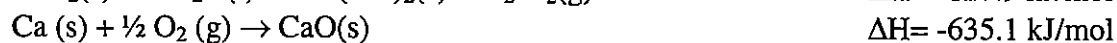
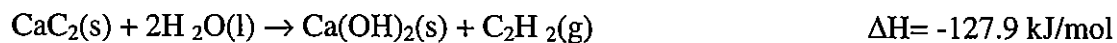
ii) If the standard enthalpies of formation of $\text{CO}_2(\text{g})$ and $\text{H}_2\text{O}(\text{l})$ are -393.5 kJ/mol and -285.8 kJ/mol respectively, calculate the standard enthalpy of formation of ethanol.

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2b) Consider the following reactions at 298.15 K.



The heat of combustion of graphite is -393.5 kJ/mol and the heat of combustion of $\text{C}_2\text{H}_2(\text{g})$ is -1299.6 kJ/mol . Calculate the heat of formation of $\text{CaC}_2(\text{s})$ at 298.15 K.

3a) A Carnot cycle heat engine does 2.50 kJ of work per cycle and has an efficiency of 45.0 %. Find Q_h and Q_c for one cycle.

3b) Calculate ΔH and ΔS for each of two blocks of Fe when they are placed into contact in an insulated container. Both blocks have the mass 1.00 kg and their initial temperatures are 200°C and 25°C. C_p for iron is $0.449 \text{ J K}^{-1} \text{ g}^{-1}$. Calculate ΔS_{total} and decide if this process is spontaneous.

4) Give brief responses to the four questions or statements below

a) For every process in an isolated system, $\Delta T = 0$.

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b) For every process in an isolated system, $\Delta S = 0$.

c) $\Delta S = 0$ for every adiabatic process in an isolated system

d) $q = 0$ for every cyclic process.