Revision

First Law of Thermodynamics

Question State whether right or wrong

Both mass and density of a gas are extensive properties ?

Answer

✗: mass is an extensive

but density is an intensive property

Question *State whether right or wrong*

- *Joule experiment can be applied for perfect gas only ?*

Answer

√

Question *State whether right or wrong*

- *4 moles of an ideal gas expands isothermally and reversibly from 2 L to 10 L, the work done under this condition is –4 J?*

Answer

$$W_b = -\int_1^2 PdV = -\int_1^2 \frac{nRT_0}{V}dV = -nRT_0\int_1^2 \frac{dV}{V} =$$

$$-nRT_0 \ln\frac{V_2}{V_1} = -P_1V_1 \ln\frac{V_2}{V_1} = -P_2V_2 \ln\frac{V_2}{V_1}$$

$$= -P_2V_2 \ln\frac{P_1}{P_2}$$

×: *missing information*

Question *State whether right or wrong*

- *The ratio between heat capacities at constant pressure and at constant volume for NH_3 equals 1.67?*

Answer

✗: *NH_3 is not a monoatomic gas. It will be less*

Question *State whether right or wrong*

- *The rate of decreasing P with V for a gas under isothermal conditions is steeper than that under adiabatic conditions ?*

Answer

✗: *the reverse is true*

Question *State whether right or wrong*

- *The state function is independent of the initial an final states but is path dependent?*

Answer

✗: *is path independent*

Question *State whether right or wrong*

- *A system containing 2 moles of CO_2 (c_p= 41 $JK^{-1}mol^{-1}$) at 400 K is heated by 2 kJ at constant pressure, the final temperature will be 424K?*

Answer

$$q_p = 2\times10^3\,J = nc_p\Delta T$$

$$= (2\,mol)\left(\frac{41\,J}{K mol}\right)(T_2 - 400K)$$

$T_2 = 424.39K$

√

Question *State whether right or wrong*

- *At inversion temperature, neither heating nor cooling occurs for a real gas?*

Answer

√

Question *State whether right or wrong*

- *For evaporation of one mole of water at 100 °C and 1 atm, the work done equals ~ 100 J?*

Answer $H_2O(l) \rightarrow H_2O(g)$

Const. P $W = -P(V_2 - V_1) \approx -PV_2 = nRT$

$$W = -(1mol)(8.314\,JK^{-1}mol^{-1})(373.15\,K) = -3.1kJ$$

×

Question *State whether right or wrong*

- *The work done by the gas adiabatically is*

$$W = -P_{ext}\left(V_2 - V_1\right) \quad ?$$

Answer

$$W = \Delta U = nC_V\left(T_2 - T_1\right)$$

✗

Question

Write the mathematical expression for

- *Kirschoff's equation*

Answer

$$\int_{\Delta H_1}^{\Delta H_2} d\Delta H = \int_{T_1}^{T_2} \Delta C_P dT$$

Assuming ΔC_P is independent of T in the assigned domain (between T_1 and T_2) therefore,

$$\Delta H_2 - \Delta H_1 = q_P = \Delta C_P\left(T_2 - T_1\right)$$

Question

Write the mathematical expression for

- *Joule-Thomson coefficient*

Answer

$$\mu = \left(\frac{\partial T}{\partial P}\right)_H$$

$$\mu = -\frac{1}{C_P}\left(\frac{\partial H}{\partial P}\right)_T = -\frac{1}{C_P}\left(\frac{\partial (U + Pv)}{\partial P}\right)_T$$

$$\mu = -\frac{1}{C_P}\left(\frac{\partial U}{\partial P}\right)_T - \frac{1}{C_P}\left(\frac{\partial Pv}{\partial P}\right)_T$$

Question

Write the mathematical expression for

- *Heat of reaction at constant pressure and that at constant volume*

- *For ideal gases: (constant n) (T is not constant), eg., expansion or compression in a closed system*
- *For ideal gases: (constant T) (n is not constant), eg., a chemical reaction or a vaporization process*

Answer

$$\Delta H = \Delta U + \Delta nRT$$
$$= \Delta U + nR\Delta T$$

$$\Delta H = \Delta U + \Delta nRT$$
$$= \Delta U + RT\Delta n$$

Question

Write the mathematical expression for

- *Free work of expansion*

Answer

Expansion against vacuum,

$$W = -P_{ext}\left(V_2 - V_1\right) = 0$$

Question

Write the mathematical expression for

- *PV-relationship for adiabatic processes*

Answer

$$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$$

Solve this problem

- *Calculate the difference between heats of a reaction at constant pressure and that at constant volume for the combustion of one mole of benzene at 25 °C according to the equation*

$$C_6H_6(l) + \frac{15}{2}O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l)$$

Solution

$$\Delta n = 6 - 7.5 = -1.5\ mol$$

$$\Delta H = \Delta U + RT\Delta n$$

$$\Delta H - \Delta U = RT\Delta n$$

$$= \left(\frac{8.314\ J}{K\ mol}\right)(298\ K)(-1.5)\left(\frac{1\ kJ}{1000\ J}\right)$$

$$\Delta H - \Delta U = -3.716\ kJ$$

Solve this problem

- *4 mole of CO_2 gas are expanded isothermally and reversibly from 3L to 5L at 25 °C. Calculate q and ΔU?*

Answer

$$W_{rev} = -nRT\ln\frac{V_2}{V_1} =$$

$$\left(-(4mol)(8.314\,JK^{-1}mol^{-1})(298K)(2.303)\log\left(\frac{5}{3}\right)\right)$$

$$= -5063\,J = -5.063\,kJ$$

Isothermally??

$$\Delta U = 0$$