16. At same temperature and pressure, equal volumes contain equal moles of gases.

Let 1.0L of CH_4 Contain 'n' mol

$\Rightarrow$ x L of CH_4 Contain nx mol

$\Rightarrow$ Heat evolved in combustion by $x\,L\,CH_4 = 809\,nx\,kJ$

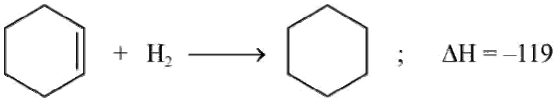
Now, $2878\,kJ$ energy is evolved from 1 mole $\left(\frac{1}{n}L\right)C_4H_{10}$

$\Rightarrow$ $809\,nx\,kJ$ Energy will be evolved from $\frac{809\,nx}{2878\,n}L$ of $C_4H_{10} = 0.28x$ L of C_4H_{10}

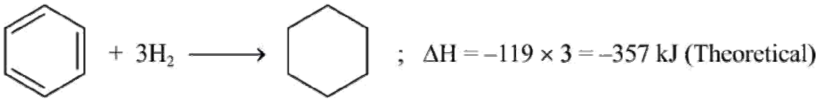
Also, the combustion reaction of butane is $C_4H_{10}+\frac{13}{2}O_2 \rightarrow 4CO_2+5H_2O$

$\Rightarrow$ Rate of supply of oxygen $=\frac{13}{2}\times 0.28x\times 3 = 5.46\,x\,L/h$

17.



$\Rightarrow$



$-357\,kJ = \Delta H_f^o(\text{cyclohexane}) - \Delta H_f^o(C_6H_6)$

$\Rightarrow$ $\Delta H_f^o(C_6H_6)_{\text{Theoretical}} = -156+357 = 201\,kJ$

$\Rightarrow$ Resonance energy $= \Delta H_f^o(\text{exp.}) - \Delta H_f^o(\text{Theoretical}) = 49-201 = -152\,kJ/mol$

18. Given: $CH_3OH(g) \rightarrow CH_3OH(l);\quad \Delta H = -38\,kJ$

$C(g)+4H(g)+O(g) \rightarrow CH_3OH(g);\quad \Delta H = -(3\times 415+356+463)$

$\because\quad H = H_1 + H_2 = -2064\,kJ$

$C(s) \rightarrow C(g);\quad \Delta H = 715\,kJ$

$2H_2(g) \rightarrow 4H(g);\quad \Delta H = 2\times 2\times 218 = 872\,kJ$

Adding : $\frac{1}{2}O_2(g) \rightarrow O(g);\quad \Delta H = 249\,kJ$

$C(gr)+2H_2(g)+\frac{1}{2}O_2(g) \rightarrow CH_3OH(l)$

$\Delta H = -265\,kJ/mol$

19. $C_3H_6 + 4.5O_2 \longrightarrow 3CO_2 + 3H_2O \qquad \Delta H = ?$

$\Delta H = 3\times -393.5 + 3\times -285.8 - 20.42 - 33 = -2091.32\ kJ$

20. $\Delta H_r^0 = \Delta H_f^0(B_2O_3) + 3\Delta H_f^0(H_2O) - \Delta H_f^o(B_2H_6)$

$\Delta H_f^o(H_2O)(g) = \Delta H_f^o(H_2O)(l) + 44 = -242\,kJ \;\Rightarrow\; \Delta H_r^o = -1273-3\times 242-36 = -2035\,kJ$

21.(B) $CO_2(g)+H_2(g) \rightarrow CO(g)+H_2O(g)$

$\Delta H = \sum \Delta_f H^o(\text{products}) - \sum \Delta_f H^o(\text{reactants})$

22.(B) Reactant should be in reference state and just one mole product should form.

23.(C) $C + O_2 \rightarrow CO_2 \quad \Delta H_1 = -393.5\,\text{kJ}$

$CO + \frac{1}{2}O_2 \rightarrow CO_2 \ \Delta H_2 = -283.5\ \text{kJ}$

$C + \frac{1}{2}O_2 \rightarrow CO \quad \Delta H_3 = ?$

$\Delta H_3 = \Delta H_1 - \Delta H_2$

24. $\Delta U = \Delta H - V\Delta P$

$= -560 - 1 \times (-30) \times 0.1 = -557\ \text{kJ}$

25.(9) Temperature rise $= T_2 - T_1 = 298.45 - 298.0.45\,\text{K}$

q = heat capacity $\times \Delta T = 2.5 \times 0.45 = 1.125\,\text{kJ}$

$\Rightarrow$ Heat produced per mole $= \frac{1.125}{3.5} \times 28 = 9\,\text{kJ}$

26.(B) ΔH_f of $Br_{2(\ell)} = 0 \qquad Br_2(g) \neq 0$

ΔH_f of $C\ell_2(g) = 0$

27.(D) For calculation of $C \equiv C$ bond energy, we must first calculate dissociation energy of C_2H_2 as

$C_2H_2(g) \rightarrow 2C(g) + 2H(g)$ ... (i)

Using the given bond energies and enthalpies:

$C_2H_2(g) \rightarrow 2C(s) + H_2(g);\ \Delta H = -225\,\text{kJ}$ ... (ii)

$2C(s) \rightarrow 2C(g); \quad \Delta H = 1410\,\text{kJ}$ ... (iii)

$H_2(g) \rightarrow 2H(g); \quad \Delta H = 330\,\text{kJ}$ ... (iv)

Adding Eqs. (ii),(iii) and (iv) gives Eq. (i)

$\Rightarrow \quad C_2H_2(g) \rightarrow 2C(g) + 2H(g); \quad \Delta = 1515\,\text{kJ}$

$\Rightarrow \quad 1515\,\text{kJ} = 2 \times (C-H)BE + (C \equiv C)BE = 2 \times 350 + (C \equiv C)BE$

$\Rightarrow \quad (C \equiv C)BE = 1515 - 700 = 815\,\text{kJ/mol}$

28.(C) $\Delta_c H^o$ (standard heat of combustion) is the standard enthalpy change when one mole of the substance is completely oxidised.

Also standard heat of formation $(\Delta_f H^o)$ can be taken as the standard of that substance.

$H^o_{CO_2} = \Delta_f H^o(CO_2) = -400\,\text{kJ mol}^{-1}$

$H^o_{H_2O} = \Delta_f H^o(H_2O) = -300\,\text{kJ mol}^{-1}$

$H^o_{glucose} = \Delta_f H^o(\text{glucose}) = -1300\,\text{kJ mol}^{-1}$

$H^o_{O_2} = \Delta_f H^o(O_2) = 0.00$

$C_6H_{12}O_6(s) + 6(O_2)(g) \rightarrow 6CO_2(g) + 6H_2O(l)$

$$\Delta_c H^o(\text{glucose}) = 6\left[\Delta_f H^o(CO_2) + \Delta_f H^o(H_2O)\right] - \left[\Delta_f H^o(C_6H_{12}O_3) + 6\Delta_f H^o(O_2)\right]$$

$$= 6[-400 - 300] - [-1300 + 6 \times 0] = -2900\,\text{kJ mol}^{-1}$$

Molar mass of $C_6H_{12}O_6 = 180\,\text{g mol}^{-1}$

Thus, standard heat of combustion of glucose per gram $= \frac{-2900}{180} = -16.11\,\text{kJ}\,\text{g}^{-1}$

To solve such problem, students are advised to keep much importance in unit conversion. As here value of R $\left(8.314\text{JK}^{-1}\text{mol}^{-1}\right)$ in $\text{JK}^{-1}\text{mol}^{-1}$ must be converted into kJ by dividing the unit by 1000.

29.(D) $C_{(\text{graphite})} + O_2(g) \rightarrow CO_2(g);\ \Delta_r H^\circ = -393.5\ \text{kJ mol}^{-1}$ ....(i)

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l);\ \ \Delta_r H^\circ = -285.8\ \text{kJ mol}^{-1}$ ....(ii)

$CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g);\ \Delta_r H^\circ = +890.3\ \text{kJ mol}^{-1}$ ....(iii)

$CO_{2(g)} + 2H_2O_{(l)} \longrightarrow CH_{4(g)} + 2O_{2(g)}$ ....(iv)

$\Delta_r H_4 = \Delta_r H_1 + 2\Delta_r H_2 + \Delta_r H_3 = -393.5 + (-285.8\times2) + 890.3 = -74.8\ \text{KJ / mol}$

30.(–14.6) $2\,Cu + \frac{1}{2}O_2(g) \longrightarrow Cu_2O(s),\quad \Delta G_1^\circ = -78\,\text{kJ}$ .... (i)

$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(g),\quad \Delta G_2^\circ = -178\,\text{kJ}$ .... (ii)

$2\,Cu(s) + H_2O(g) \longrightarrow Cu_2O(s) + H_2(g),\ \ \Delta G_3^\circ = 100\,\text{kJ}$ .... (iii)

Eq.(i) − Eq.(ii) = Eq.(iii)

$\Delta G = \Delta G^\circ + RT\ell n\,Q\ ;\ \Delta G = 0$ (for min)

$$\Rightarrow \quad 0 = 100 + \frac{8}{1000}\times 1250\,\ell n\frac{P_{H_2}}{P_{H_2O}} \quad \Rightarrow \quad -\frac{10^5}{8} = 1250\,\ell n\frac{P_{H_2}}{\left(\frac{1}{100}\times 1\right)} \qquad \text{(1 \% of 1 bar)}$$

$$\Rightarrow \quad -10 = \ell n\,P_{H_2}\times 100 \quad \Rightarrow \quad -10 = \ell n\,P_{H_2}\times \ell n\,10^2$$

$$P_{H_2} = -10 - 4.6 = -14.6$$

31.(CD) Standard formation of enthalpy is the enthalpy involved in the reaction when one mole of a substance is formed from its constituent elements in their standard elemental state.

$$\left.\begin{aligned} \frac{1}{8}S_8(s) + O_2(g) &\longrightarrow SO_2(g) \\ \frac{3}{2}O_2(g) &\longrightarrow O_3(g) \end{aligned}\right\}\text{formation reactions}$$