**Marks
2**
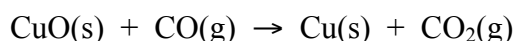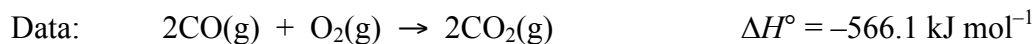
- Copper metal can be obtained by heating copper oxide , CuO, in the presence of carbon monoxide, CO, according to the following reaction.

$$CuO(s) + CO(g) \rightarrow Cu(s) + CO_2(g)$$

Calculate $\Delta H°$ for this reaction in kJ mol^{-1}.

Data: $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$ $\Delta H° = -566.1$ kJ mol^{-1}

              $2Cu(s) + O_2(g) \rightarrow 2CuO(s)$ $\Delta H° = -310.5$ kJ mol^{-1}

Using $\Delta_r H° = \sum\Delta_f H°$(products) – $\sum\Delta_f H°$(reactants), the enthalpy changes in the 3 reactions are, respectively:

$\Delta_r H°(1) = \Delta_f H°(CO_2(g)) – [\Delta_f H°(CuO(s)) + \Delta_f H°(CO(g))]$

$\Delta_r H°(2) = 2\Delta_f H°(CO_2(g)) – 2\Delta_f H°(CO(g)) = -566.1$ **kJ mol**$^{-1}$
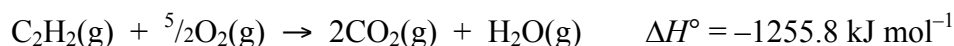
$\Delta_r H°(3) = 2\Delta_f H°(CuO(s)) = -310.5$ **kJ mol**$^{-1}$

Using $\Delta_f H° = 0$ for Cu(s) and O_2(g) as these are elements in their standard states.

Rearranging (1) gives:

$\Delta_r H°(1) = \Delta_f H°(CO_2(g)) – \Delta_f H°(CO(g)) – \Delta_f H°(CuO(s))$

$= ½ (\Delta_r H°(2)) - ½ (\Delta_r H°(3))$

$= [½ (-566.1) – ½ (-310.5)]$ **kJ mol**$^{-1}$ **= -127.8 kJ mol**$^{-1}$

Answer: **-127.8 kJ mol**$^{-1}$

- Acetylene burns in air according to the following equation:

$$C_2H_2(g) + {}^5\!/_2 O_2(g) \rightarrow 2CO_2(g) + H_2O(g)   \Delta H° = -1255.8 \text{ kJ mol}^{-1}$$

The $\Delta_f H°$ of CO_2(g) $= -393.5$ kJ mol^{-1}, $\Delta_f H°$ of H_2O(l) $= -285.8$ kJ mol^{-1} and $\Delta_{vap} H°$ of H_2O(l) $= +44.0$ kJ mol^{-1}. What is $\Delta_f H°$ of C_2H_2(g)?

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Using $\Delta_r H° = \sum\Delta_f H°$(products) – $\sum\Delta_f H°$(reactants), the enthalpy of combustion of C_2H_2(g) is:

$\Delta_{comb} H°(C_2H_2(g)) = [2\Delta_f H°(CO_2(g)) + \Delta_f H°(H_2O(g))]$
                         $– \Delta_f H°(C_2H_2(g)) = -1255.8$ **kJ mol**$^{-1}$

The enthalpy of vaporisation for H_2O(g) corresponds to H_2O(l) → H_2O(g):

$\Delta_{vap} H°(H_2O(l)) = \Delta_f H°(H_2O(g)) - \Delta_f H°(H_2O(l)) = +44.0$ **kJ mol**$^{-1}$

and so,

$\Delta_f H°(H_2O(g)) = \Delta_{vap} H°(H_2O(l)) + \Delta_f H°(H_2O(l))$
            $= (+44.0 + -285.8)$ **kJ mol**$^{-1}$ **= -241.8 kJ mol**$^{-1}$

ANSWER CONTINUES ON THE NEXT PAGE

Substituting the data into the expression for $\Delta_{comb}H°(C_2H_2(g))$

$\Delta_{comb}H°(C_2H_2(g)) = [(2 \times -393.5 + -241.8)$
$- \Delta_fH°(C_2H_2(g))]$ kJ mol^{-1} = -1255.8 kJ mol^{-1}

So:

$\Delta_fH°(C_2H_2(g) = [(2 \times -393.5 + -241.8) + 1255.8]$ kJ mol^{-1} = +227.0 kJ mol^{-1}

Answer: **+227.0 kJ mol^{-1}**