# AHL Worksheet – Chapter 5

**1** Write equations to represent the enthalpy change of formation of the following: [3]

**a** $C_6H_6(l)$

**b** $CH_3CHO(l)$

**c** $Li_3N(s)$

**2** Calculate the enthalpy change of formation of each of the following given the data in the table: [12]

| | $\Delta H_c^\ominus$ / kJ mol$^{-1}$ |
|---|---|
| C(s) | –394 |
| $H_2(g)$ | –286 |
| $CH_3CH_2CH_3(g)$ | –2220 |
| $CH_3OH(l)$ | –715 |
| HCHO(g) | –561 |
| $CH_3COOH(l)$ | –876 |

**a** propane, $CH_3CH_2CH_3(g)$

**b** methanol, $CH_3OH(l)$

**c** methanal, HCHO(g)

**d** ethanoic acid, $CH_3COOH(l)$

**3** Calculate the enthalpy change of combustion of each of the following given the data in the table. [12]

| | $\Delta H_f^\ominus$ / kJ mol$^{-1}$ |
|---|---|
| $CO_2(g)$ | –394 |
| $H_2O(l)$ | –286 |
| $C_6H_{12}(l)$ | –156 |
| $C_6H_5OH(s)$ | –163 |
| $CH_2CHCHCH_2(g)$ | 112 |
| $(CH_3)_2O(g)$ | –185 |

**a** cyclohexane, $C_6H_{12}(l)$

**b** phenol, $C_6H_5OH(s)$

**c** buta-1,3-diene, $CH_2CHCHCH_2(g)$

**d** methoxymethane, $(CH_3)_2O(g)$

**4** Calculate the enthalpy changes for the following reactions given the data in the table.

| | $\Delta H_f^\ominus$ / kJ mol$^{-1}$ |
|---|---|
| $SO_2(g)$ | –297 |
| $PCl_5(s)$ | –444 |
| $SOCl_2(l)$ | –246 |
| $Cl_2O(g)$ | 80 |
| $POCl_3(l)$ | –597 |
| $NH_3(g)$ | –46 |
| $NH_4Cl(s)$ | –314 |
| $H_2O(g)$ | –242 |

**a** $SO_2(g) + PCl_5(s) \rightarrow SOCl_2(l) + POCl_3(l)$ [2]

**b** $3Cl_2O(g) + 10NH_3(g) \rightarrow 2N_2(g) + 6NH_4Cl(s) + 3H_2O(g)$ [2]

**5** Use the information below to calculate the enthalpy change of formation of ClNO(g) [2]

$NCl_3(l) + 2NO(g) \rightarrow ClNO(g) + N_2O(g) + Cl_2(g)$ $\Delta H^\ominus = -276$ kJ mol$^{-1}$

| | $\Delta H_f^\ominus$ / kJ mol$^{-1}$ |
|---|---|
| $NCl_3(l)$ | 230 |
| $NO(g)$ | 90 |
| $N_2O(g)$ | 82 |

**6** Write equations to represent the following processes: [3]

**a** the second ionisation energy of magnesium

**b** the first electron affinity of oxygen

**c** the lattice enthalpy of magnesium fluoride

**7** Construct a Born–Haber cycle showing the formation of calcium fluoride and use it and the data in the table below to predict the lattice enthalpy of calcium fluoride. [6]

| | |
|---|---|
| $\Delta H_{at}(Ca(s))$ | 193 kJ mol$^{-1}$ |
| $\Delta H_{at}(F_2(g))$ | 79 kJ mol$^{-1}$ |
| first ionisation energy (Ca) | 590 kJ mol$^{-1}$ |
| second ionisation energy (Ca) | 1150 kJ mol$^{-1}$ |
| first electron affinity (F) | –348 kJ mol$^{-1}$ |
| $\Delta H_f(CaF_2(s))$ | –1214 kJ mol$^{-1}$ |

**8** State and explain the trends in lattice enthalpy shown in the table below. [6]

| Substance | Lattice enthalpy / kJ mol$^{-1}$ |
|---|---|
| LiF | 1022 |
| NaF | 902 |
| KF | 801 |
| MgO | 3889 |
| CaO | 3513 |
| SrO | 3310 |

**9** Predict, with a reason, whether each of the following reactions involves an increase or decrease in entropy.

**a** $3Cl_2O(g) + 10NH_3(g) \rightarrow 2N_2(g) + 6NH_4Cl(s) + 3H_2O(g)$ [2]

**b** $NCl_3(l) + 2NO(g) \rightarrow ClNO(g) + N_2O(g) + Cl_2(g)$ [2]

**10** Use the data in the table to calculate the entropy change for the following reactions:

| | $S^\ominus$ / J K$^{-1}$ mol$^{-1}$ |
|---|---|
| $SO_2(g)$ | 248 |
| $PCl_5(s)$ | 167 |
| $SOCl_2(l)$ | 308 |
| $N_2H_4(l)$ | 121 |
| $POCl_3(l)$ | 223 |
| $O_2(g)$ | 205 |
| $N_2(g)$ | 192 |
| $H_2O(g)$ | 188 |

**a** $SO_2(g) + PCl_5(s) \rightarrow SOCl_2(l) + POCl_3(l)$ [2]

**b** $N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$ [2]

**11** Use your answers from questions 4 and 10 to predict whether the reaction:

$SO_2(g) + PCl_5(s) \rightarrow SOCl_2(l) + POCl_3(l)$

is spontaneous at 298 K. [4]

**12** **a** Use the values given in the table to calculate $\Delta G^\ominus$ for the reaction:

$Cl_2(g) + 2NO(g) \rightarrow 2ClNO(g)$ [2]

| | $\Delta G_f^\ominus$ / kJ mol$^{-1}$ |
|---|---|
| ClNO(g) | 66 |
| NO(g) | 87 |

**b** Predict whether this reaction will be more spontaneous at 300 K or 500 K. [3]