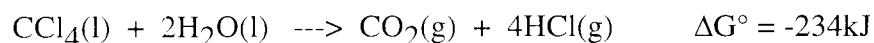
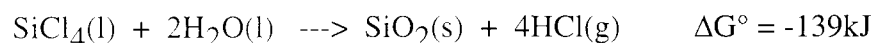


1. The following equations refer to two hydrolyses:



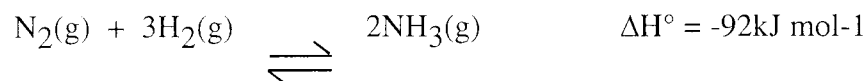
- (a) **From this information alone** what predictions can be made about their
- feasibility
 - position of equilibrium
 - rate?
- (b) In practice, the addition of water to tetrachlorosilane (SiCl_4) results in an immediate vigorous hydrolysis. The addition of water to tetrachloromethane (CCl_4) has no effect even with prolonged boiling.
Suggest, in terms of energy, an explanation for this difference.

2. Iodine molecules can be converted into iodine atoms in the reaction shown below.



- (a) What name is given to this enthalpy change?
- (b) At 298K, the Gibbs free energy change for the reaction is -261kJ
Calculate:
- the standard entropy change for the reaction shown;
 - the standard entropy of gaseous iodine atoms.

3. The Haber process (arghh, not another question based on the Haber process!!) is represented by the equation.



2 moles of each reactant were allowed to react and come to equilibrium in a 1 litre container at 400K. At equilibrium 0.4 moles of ammonia had been formed.

- (a) Write the expression for the equilibrium constant, K, for the above reaction.
- (b) Calculate
- the equilibrium concentrations of both nitrogen and hydrogen.
 - the value of the equilibrium constant at 400K.
- (c) Explain what will happen to the value of the equilibrium constant if the temperature is increased from 400K to 600K

1. (a) (i) both feasible ΔG -ve

(ii) both equilibrium will be to the right favouring products

(iii) none, thermodynamics gives no information on speed of reactions

(b) activation energy for hydrolysis of tetrachlorosilane is low but high for the hydrolysis of tetrachloromethane

2. (a) Atomisation or

$$(b) (i) \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta S^\circ = -\left(\frac{\Delta G^\circ - \Delta H^\circ}{T}\right) = -\left(\frac{-261 - (+149)}{298}\right)$$

$$= -\left(\frac{-410}{298}\right)$$

$$= \underline{1.3758 \text{ kJ K}^{-1} \text{ mol}^{-1}}$$

$$(ii) \Delta S^\circ = S^\circ_{\text{products}} - S^\circ_{\text{reactants}}$$

$$(\text{I}_2(g) \rightarrow 2\text{I}(g)) = S^\circ_{2\text{I}(g)} - S^\circ_{\text{I}_2(g)}$$

$$S^\circ_{2\text{I}(g)} = \Delta S^\circ + S^\circ_{\text{I}_2(g)} \quad \begin{array}{l} \text{from data book} \\ \uparrow \end{array}$$
$$= 1376 + 116.1 = 1492.1$$

$$S^\circ_{\text{I}(g)} = \frac{1492.1}{2} = \underline{746.05 \text{ J K}^{-1} \text{ mol}^{-1}}$$

3. (a)

$$K = \frac{[\text{NH}_3]^2}{[\text{H}_2]^3 [\text{N}_2]}$$

(b) (i) moles N_2 at equilibrium = moles at start - moles reacted

$$= 2 - (0.4 \times \frac{1}{2})$$

$$= 1.8$$

$$\text{conc } \text{N}_2 = \underline{1.8 \text{ mole/l}} \text{ (since vol = 1 l)}$$

moles H_2 at equilibrium = moles at start - moles reacted

$$= 2 - (0.4 \times \frac{3}{2})$$

$$= 1.4$$

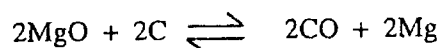
$$\text{conc } \text{H}_2 = \underline{1.4 \text{ mole/l}}$$

(ii)

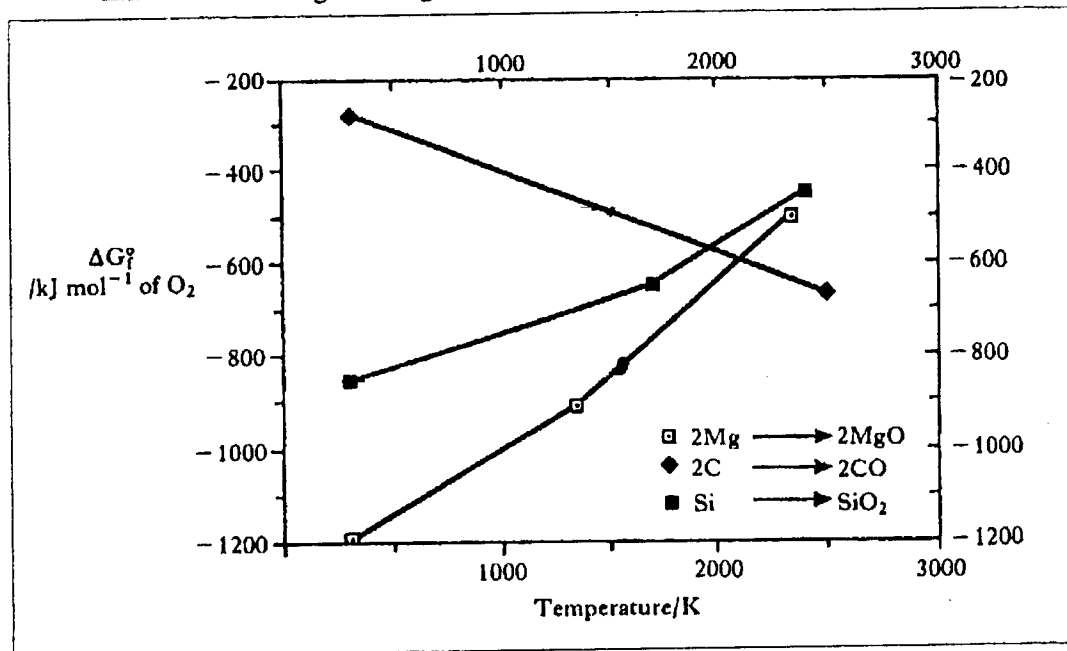
$$K = \frac{[\text{NH}_3]^2}{[\text{H}_2]^3 [\text{N}_2]} = \frac{0.4^2}{1.4^3 \times 1.8} = \frac{0.16}{2.744 \times 1.8}$$
$$= \frac{0.16}{4.932}$$

(c) K will decrease as increasing temp will favour endo direction
Reactants therefore K will decrease

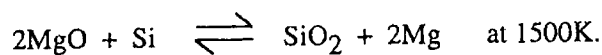
1. Although magnesium ores are very abundant in the earth's crust, the very high reactivity of magnesium makes it difficult to extract the metal. During the second world war, magnesium was manufactured by reduction of its oxide by carbon.



Examine the Ellingham diagram below and answer the questions which follow.

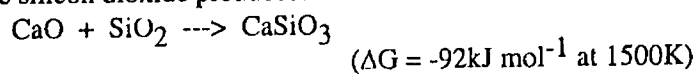


- (a) Explain why the magnesium is continuously removed from the reaction mixture.
 (b) In what temperature range is the reaction thermodynamically feasible?
 (c) Use the Ellingham diagram to calculate ΔG° for the production of magnesium by the following reaction:



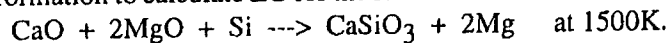
- (d) In industry the extraction of magnesium from magnesium oxide using silicon involves two modifications from the simple reaction above.

- (i) A mixture of calcium oxide and magnesium oxide is used, the calcium oxide reacts with the silicon dioxide produced.



- (ii) The gaseous magnesium is continuously removed from the reaction mixture.

Use this information to calculate ΔG for the reaction



1. (a) Since reactions is reversible removing Mg prevent reaction reaching equilibrium and therefore allow reaction to go to completion.

(b) above 2100 °K

(c) ΔG° (redox) = ΔG° (oxidation) + ΔG° (reduction)

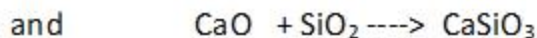
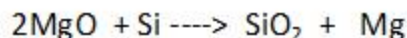
$$= \Delta G^\circ (\text{Si} + \text{O}_2 \rightarrow \text{SiO}_2) + \Delta G^\circ (2\text{MgO} \rightarrow 2\text{Mg} + \text{O}_2)$$

$$= -700 + 850$$

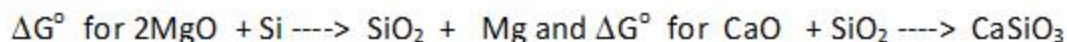
$$= + 150 \text{ kJ mol}^{-1}$$

(equilibrium position will greatly favour reactants over products)

(d) Required equation $\text{CaO} + 2\text{MgO} + \text{Si} \rightarrow \text{CaSiO}_3 + \text{Mg}$ can be obtained by adding the following two equations



so ΔG° for $\text{CaO} + 2\text{MgO} + \text{Si} \rightarrow \text{CaSiO}_3 + \text{Mg}$ can be calculated by adding



thus ΔG° for $\text{CaO} + 2\text{MgO} + \text{Si} \rightarrow \text{CaSiO}_3 + \text{Mg} = 150 + (-92) = +58 \text{ kJ mol}^{-1}$ of Mg

(equilibrium position will move more to products side but will still favour reactants)