

Name of the Student: _____

Max. Marks : 25 Marks

Time : 25 Minutes

Q1.

Thermodynamics can be used to investigate the changes that occur when substances such as calcium fluoride dissolve in water.

(a) Give the meaning of each of the following terms.

(i) enthalpy of lattice formation for calcium fluoride

(2)

(ii) enthalpy of hydration for fluoride ions

(1)

(b) Explain the interactions between water molecules and fluoride ions when the fluoride ions become hydrated.

(2)

(c) Consider the following data.

	$\Delta H^\ominus / \text{kJ mol}^{-1}$
Enthalpy of lattice formation for CaF_2	-2611
Enthalpy of hydration for Ca^{2+} ions	-1650
Enthalpy of hydration for F^- ions	-506

Use these data to calculate a value for the enthalpy of solution for CaF_2

(2)

(Total 7 marks)

Q2.

When potassium nitrate (KNO_3) dissolves in water the value of the enthalpy change $\Delta H = +34.9 \text{ kJ mol}^{-1}$ and the value of the entropy change $\Delta S = +117 \text{ J K}^{-1} \text{ mol}^{-1}$.

- (a) Write an equation, including state symbols, for the process that occurs when potassium nitrate dissolves in water.

(1)

- (b) Suggest why the entropy change for this process is positive.

(1)

- (c) Calculate the temperature at which the free-energy change, ΔG , for this process is zero.

(3)

- (d) (i) Deduce what happens to the value of ΔG when potassium nitrate dissolves in water at a temperature lower than your answer to part (c).

(1)

- (ii) What does this new value of ΔG suggest about the dissolving of potassium nitrate at this lower temperature?

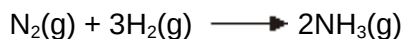
(1)

(Total 7 marks)

Q3.

Ammonia can be manufactured by the Haber Process.

The equation for the reaction that occurs is shown below.



(a) The table below contains some bond enthalpy data.

	$\text{N} \equiv \text{N}$	$\text{H}-\text{H}$	$\text{N}-\text{H}$
Mean bond enthalpy / kJ mol^{-1}	944	436	388

(i) Use data from the table to calculate a value for the enthalpy of formation for one mole of ammonia.

(3)

(ii) A more accurate value for the enthalpy of formation of ammonia is -46 kJ mol^{-1} .

Suggest why your answer to part (a) (i) is different from this value.

(1)

(b) The table below contains some entropy data.

	$\text{H}_2(\text{g})$	$\text{N}_2(\text{g})$	$\text{NH}_3(\text{g})$
$S^\ominus / \text{J K}^{-1} \text{ mol}^{-1}$	131	192	193

Use these data to calculate a value for the entropy change, with units, for the formation of one mole of ammonia from its elements.

(3)

(c) The synthesis of ammonia is usually carried out at about 800 K.

- (i) Use the ΔH value of -46 kJ mol^{-1} and your answer from part (b) to calculate a value for ΔG , with units, for the synthesis at this temperature.
(If you have been unable to obtain an answer to part (b), you may assume that the entropy change is $-112 \text{ J K}^{-1} \text{ mol}^{-1}$. This is not the correct answer.)

(3)

- (ii) Use the value of ΔG that you have obtained to comment on the feasibility of the reaction at 800 K.

(1)

(Total 11 marks)