

Name of the Student: \_\_\_\_\_

Max. Marks : 18 Marks

Time : 18 Minutes

Q1.

A value for enthalpy of solution can be determined in two ways:

- from a cycle, using lattice enthalpy and enthalpies of hydration
- from the results of a calorimetry experiment.

(a) Define the term enthalpy of lattice dissociation.

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(2)

(b) The enthalpy of solution for ammonium nitrate is the enthalpy change for the reaction shown.

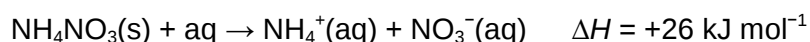


Table 1

|                                                                   | $\text{NH}_4^+(\text{g})$ | $\text{NO}_3^-(\text{g})$ |
|-------------------------------------------------------------------|---------------------------|---------------------------|
| Enthalpy of hydration $\Delta_{\text{hyd}}H / \text{kJ mol}^{-1}$ | -307                      | -314                      |

Draw a suitably labelled cycle and use it, with data from **Table 1**, to calculate the enthalpy of lattice dissociation for ammonium nitrate.

Enthalpy of lattice dissociation \_\_\_\_\_  $\text{kJ mol}^{-1}$ 

(3)

(c) A student does an experiment to determine a value for the enthalpy of solution for ammonium nitrate.

The student uses this method.

- Measure 25.0 cm<sup>3</sup> of distilled water in a measuring cylinder.
- Pour the water into a beaker.
- Record the temperature of the water in the beaker.
- Add 4.00 g of solid NH<sub>4</sub>NO<sub>3</sub> to the water in the beaker.
- Stir the solution and record the lowest temperature reached.

**Table 2** shows the student's results.

**Table 2**

|                          |      |
|--------------------------|------|
| Initial temperature / °C | 20.2 |
| Lowest temperature / °C  | 12.2 |

Calculate the enthalpy of solution, in kJ mol<sup>-1</sup>, for ammonium nitrate in this experiment.

Assume that the specific heat capacity of the solution,  $c = 4.18 \text{ J K}^{-1} \text{ g}^{-1}$

Assume that the density of the solution = 1.00 g cm<sup>-3</sup>

Enthalpy of solution \_\_\_\_\_ kJ mol<sup>-1</sup>

**(3)**

- (d) The uncertainty in each of the temperature readings from the thermometer used in this experiment is  $\pm 0.1^\circ\text{C}$

Calculate the percentage uncertainty in the temperature change in this experiment.

Percentage uncertainty \_\_\_\_\_

**(1)**

- (e) Suggest a change to the student's method, using the same apparatus, that would reduce the percentage uncertainty in the temperature change.

Give a reason for your answer.

Change \_\_\_\_\_

Reason \_\_\_\_\_

(2)

- (f) Another student obtained a value of  $+15 \text{ kJ mol}^{-1}$  using the same method.

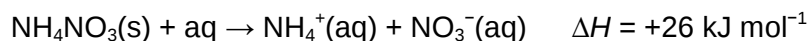
Suggest the main reason for the difference between this experimental value for the enthalpy of solution and the correct value of  $+26 \text{ kJ mol}^{-1}$

(1)

- (g) **Table 3** shows some entropy data at 298 K

| <b>Table 3</b>                     |                                                                  |
|------------------------------------|------------------------------------------------------------------|
|                                    | <b>Entropy <math>S / \text{J K}^{-1} \text{ mol}^{-1}</math></b> |
| $\text{NH}_4\text{NO}_3(\text{s})$ | 151                                                              |
| $\text{NH}_4^+(\text{aq})$         | 113                                                              |
| $\text{NO}_3^-(\text{aq})$         | 146                                                              |

Calculate a value for the Gibbs free-energy change ( $\Delta G$ ), at 298 K, for the reaction when ammonium nitrate dissolves in water.



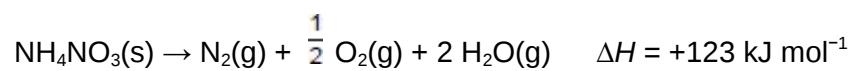
Use data from **Table 3** and the value of  $\Delta H$  from the equation.  
Assume for the solvent, water, that the entropy change,  $\Delta S = 0$

Explain what the calculated value of  $\Delta G$  indicates about the feasibility of this reaction at 298 K

$\Delta G$  \_\_\_\_\_  $\text{kJ mol}^{-1}$

Explanation \_\_\_\_\_

(h) Ammonium nitrate decomposes as shown.



The entropy change ( $\Delta S$ ) for this reaction is  $+144 \text{ J K}^{-1} \text{ mol}^{-1}$

Calculate the temperature at which this reaction becomes feasible.

Temperature \_\_\_\_\_ K  
(2)  
(Total 18 marks)