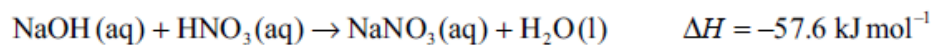




- (a) The equation for the reaction between sodium hydroxide, NaOH, and nitric acid, HNO<sub>3</sub>, is shown below.



- (i) Sketch and label an enthalpy level diagram for this reaction. [3]

- (ii) Deduce whether the reactants or the products are more energetically stable, stating your reasoning. [1]



# TOPPERZ @ WORK EDUCATION CENTRE

CLASS: IB YEAR 2

TIME: 30 MINUTES

TOPIC: ACID & BASE (IONIC EQUILIBRIUM)

- (iii) Calculate the change in heat energy, in kJ, when  $50.0 \text{ cm}^3$  of  $2.50 \text{ mol dm}^{-3}$  sodium hydroxide solution is added to excess nitric acid. [2]

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- (b) When ammonium chloride,  $\text{NH}_4\text{Cl}(\text{aq})$ , is added to excess solid sodium carbonate,  $\text{Na}_2\text{CO}_3(\text{s})$ , an acid-base reaction occurs. Bubbles of gas are produced and the solid sodium carbonate decreases in mass. State **one** difference which would be observed if nitric acid,  $\text{HNO}_3(\text{aq})$ , was used instead of ammonium chloride. [1]

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- (c) When  $5.35 \text{ g}$  ammonium chloride,  $\text{NH}_4\text{Cl}(\text{s})$ , is added to  $100.0 \text{ cm}^3$  of water, the temperature of the water decreases from  $19.30 \text{ }^\circ\text{C}$  to  $15.80 \text{ }^\circ\text{C}$ . Determine the enthalpy change, in  $\text{kJ mol}^{-1}$ , for the dissolving of ammonium chloride in water. [3]

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# TOPPERZ @ WORK EDUCATION CENTRE

CLASS: IB YEAR 2

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TOPIC: ACID & BASE (IONIC EQUILIBRIUM)

- (d) A solution of ammonia has a concentration of  $0.500 \text{ mol dm}^{-3}$ .

Calculate the pH of the ammonia solution using information from Table 15 of the Data Booklet. State **one** assumption made.

[4]

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- (e) A buffer solution is made using  $25.0 \text{ cm}^3$  of  $0.500 \text{ mol dm}^{-3}$  nitric acid,  $\text{HNO}_3(\text{aq})$ , and  $25.0 \text{ cm}^3$  of  $1.00 \text{ mol dm}^{-3}$  ammonia solution,  $\text{NH}_3(\text{aq})$ .

- (i) State the meaning of the term *buffer solution*.

[1]

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- (ii) Calculate the concentrations of ammonia and ammonium ion in the buffer solution.

[2]

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# TOPPERZ @ WORK EDUCATION CENTRE

CLASS: IB YEAR 2

TIME: 30 MINUTES

TOPIC: ACID & BASE (IONIC EQUILIBRIUM)

- (iii) Determine the pH of the buffer solution at 25 °C. [2]

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- (iv) Explain why the pH of the buffer solution is different from the pH of the ammonia solution calculated in (d). [1]

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- (v) Explain the action of the buffer solution when a few drops of nitric acid solution are added to it. [2]

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(f) Bromocresol green is an acid–base indicator. Information about bromocresol green is given in Table 16 of the Data Booklet.

(i) Identify the property of bromocresol green that makes it suitable to use as an acid–base indicator. [1]

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(ii) State and explain the relationship between the pH range of bromocresol green and its  $pK_a$  value. [2]

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