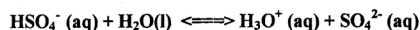


[31 marks]

Name: SOLUTIONS

## Question 1



In the equilibrium represented above, the species that act as bases include which of the following?

- I.  $\text{HSO}_4^-$   
 II.  $\text{H}_2\text{O}$   
 III.  $\text{SO}_4^{2-}$

- (A) II only  
 (B) III only  
 (C) I and II  
 (D) I and III  
 (E) II and III

## Question 2

Which of the following is NOT a conjugate acid/base pair?

- (A)  $\text{H}_3\text{PO}_4 / \text{HPO}_4^{2-}$   
 (B)  $\text{H}_2\text{SO}_4 / \text{HSO}_4^-$   
 (C)  $\text{H}_2\text{CO}_3 / \text{HCO}_3^-$   
 (D)  $\text{NH}_3 / \text{NH}_2^-$

## Question 3

The Brønsted-Lowry theory applies in both aqueous and non-aqueous systems.

The following reactions may take place in solvents other than water.

Which is NOT a Brønsted-Lowry reaction?

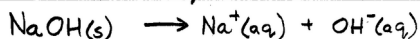
- (A)  $\text{NH}_4^+ + \text{NH}_2^- \rightleftharpoons 2\text{NH}_3$   
 (B)  $\text{CO}_2 + \text{OH}^- \rightleftharpoons \text{HCO}_3^-$   
 (C)  $\text{HClO}_4 + \text{CH}_3\text{COOH} \rightleftharpoons \text{CH}_3\text{COOH}_2^+ + \text{ClO}_4^-$   
 (D)  $\text{CH}_3\text{CH}_2\text{O}^- + \text{CH}_3\text{NH}_3^+ \rightleftharpoons \text{CH}_3\text{CH}_2\text{OH} + \text{CH}_3\text{NH}_2$

## Question 4

Define each of the following giving a *real* chemical equation to illustrate your definition.

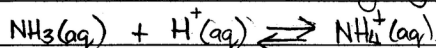
(a) An Arrhenius base.

A substance that produces  $\text{OH}^-$  in solution.



(b) A Brønsted-Lowry base.

A substance that accepts hydrogen ions



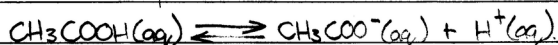
Brønsted-Lowry Base

## Question 5

(a) Is acetic acid a non-electrolyte, a weak electrolyte or a strong electrolyte? Why?

(2 marks)

A weak electrolyte because it only partially ionises in solution.

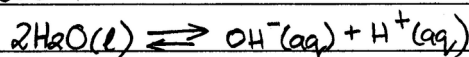


Two ARROWS

(b) Is water a non-electrolyte, a weak electrolyte or a strong electrolyte? Why?

(2 marks)

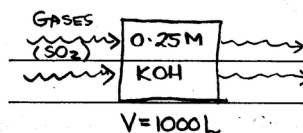
A weak electrolyte because it partially ionises



## Question 6

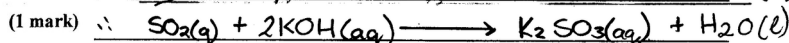
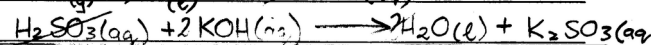
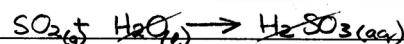
It is suggested that  $\text{SO}_2$  which contributes to acid rain, could be removed from a stream of waste gases by bubbling the gases through 0.25 M KOH, thereby producing  $\text{K}_2\text{SO}_3$ . Calculate the maximum mass of  $\text{SO}_2$  that could be removed by 1000 L of the KOH solution?

(5 marks)



$$n(\text{KOH}) = C \times V$$

$$= 0.25 \times 1000 = 250 \text{ moles}$$



$$n(\text{SO}_2) = \frac{n(\text{KOH})}{2} = \frac{250}{2} = 125 \text{ moles}$$

$$m(\text{SO}_2) = n(\text{SO}_2) \times M(\text{SO}_2)$$

$$= 125 \times (32.06 + [2 \times 16.00])$$

$$= 8007.5 \text{ g}$$

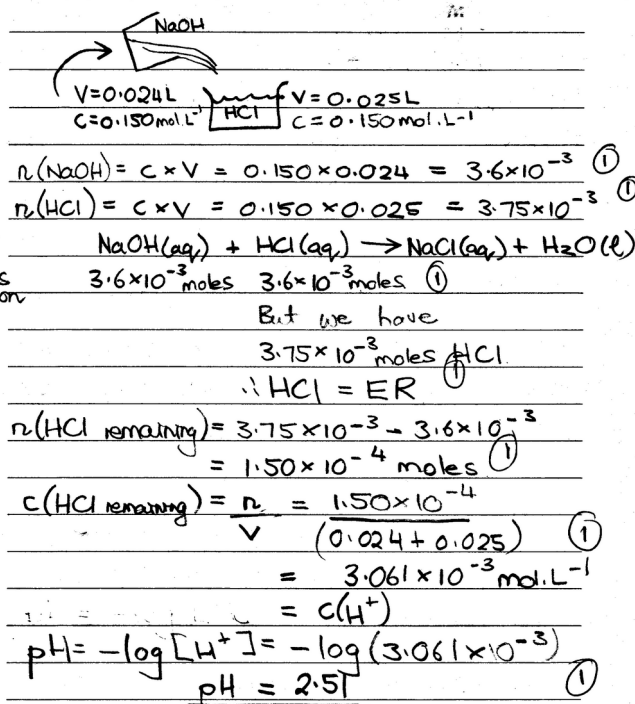
$$\therefore 8.00 \text{ kg}$$

## Question 7

24.0 mL of 0.150 mol  $\text{L}^{-1}$  NaOH is added to 25.0 mL of 0.150 mol  $\text{L}^{-1}$  HCl.

Calculate the pH of the final solution.

(7 marks)



### Question 8

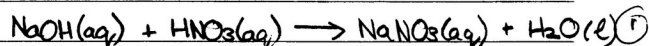
0.300 g of solid NaOH was added to 1.00 L of  $5.00 \times 10^{-3} \text{ mol L}^{-1} \text{ HNO}_3$ .

(a) Which reactant was in excess? Explain your answer.

(5 marks)

$$n(\text{NaOH}) = \frac{m}{M} = \frac{0.300}{23+16+1} = 7.5 \times 10^{-3} \text{ moles} \quad (1)$$

$$n(\text{HNO}_3) = C \times V = 5.00 \times 10^{-3} \times 1 = 5.00 \times 10^{-3} \text{ moles} \quad (1)$$



$5.00 \times 10^{-3}$  moles  $\text{HNO}_3$  reacts

with  $5.00 \times 10^{-3}$  moles  $\text{NaOH}$ . (1)

But we have  $7.5 \times 10^{-3} \text{ moles}$  of  $\text{NaOH}$

$$> 5.00 \times 10^{-3} \quad (1)$$

$\therefore \text{NaOH}$  is excess reagent

(b) Assuming no volume change, what is the pH of the final solution?

(3 marks)

$$n(\text{NaOH remaining}) = n(\text{NaOH in beginning}) - n(\text{NaOH reacting})$$

$$= 7.5 \times 10^{-3} - 5.00 \times 10^{-3}$$

$$2.5 \times 10^{-3}$$

$$C(\text{NaOH}) = n/V = \frac{2.5 \times 10^{-3}}{1} = 2.5 \times 10^{-3} \text{ M}$$

$$= C(\text{OH}^-)$$

$$\text{pOH} = -\log[\text{OH}^-] = -\log(2.5 \times 10^{-3}) = 2.602$$

$$\text{pH} = 14 - \text{pOH}$$

$$= 14 - 2.602$$

$$= 11.4$$