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Level 3 Chemistry, 2006

90700 Describe properties of aqueous systems

Credits: Five

You should answer ALL the questions in this booklet.

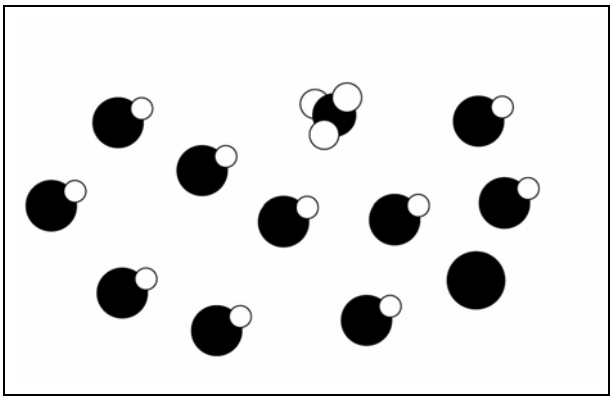
For Assessor's use only	**Achievement Criteria**	
Achievement	**Achievement with Merit**	**Achievement with Excellence**
Describe properties of aqueous systems.	Explain and apply properties of aqueous systems.	Discuss properties of aqueous systems
Overall Level of Performance		

You are advised to spend 45 minutes answering the questions in this booklet.

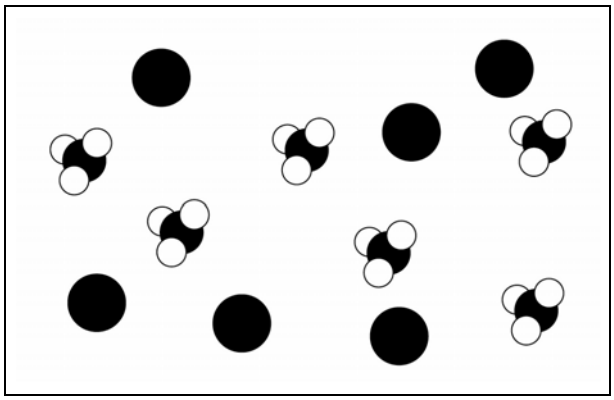
QUESTION ONE: PARTICLES IN SOLUTIONS

The boxes below show particle representations of the species (excluding water) in four aqueous solutions.

A



B



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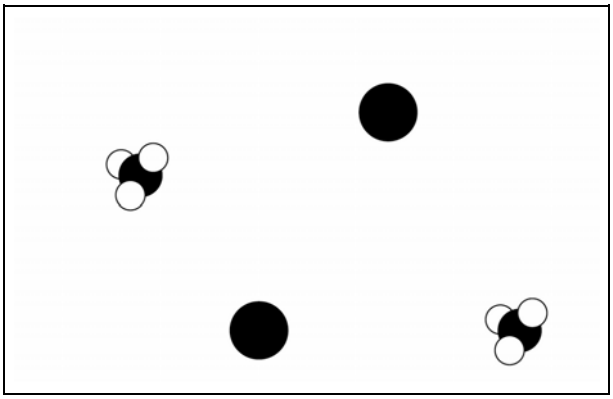

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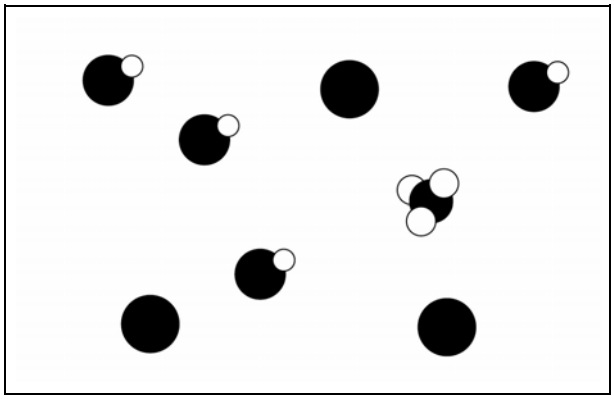


= HA = A^- = H_3O^+

(a) Choose the box that **best** illustrates each of the solutions (i)–(iii) below. In each case, give a reason for your answer.

(i) A **dilute solution** of a **strong acid**

Box:

Reason:

(ii) A **concentrated solution** of a **weak acid**

Box:

Reason:

(iii) A **buffer solution**

Box:

Reason:

(b) Explain how the **pH** and **buffering properties** of the buffer solution would be affected if it were diluted by a factor of 10.

QUESTION TWO: EXTRACTION OF SALT

Sea-water contains appreciable amounts of ions other than Na^+ and Cl^-. One substance that is less soluble than sodium chloride is calcium sulfate. This is precipitated in the first stage of the purification process used to produce table salt (sodium chloride).

$$K_s\ (CaSO_4) = 2.45 \times 10^{-5}$$

(a) (i) Write the equation for the equilibrium reaction in a saturated solution of calcium sulfate.

(ii) Calculate the solubility of $CaSO_4$ in water.

Evaporating the sea-water to dryness would produce a mixture of salts including NaCl. However, precipitation of NaCl occurs if concentrated hydrochloric acid is added to a saturated NaCl solution.

(b) Explain why this precipitation occurs.

As part of the process for extracting table salt from sea-water, sodium hydroxide is added to the sea-water to precipitate the magnesium ions as magnesium hydroxide. The concentration of Mg^{2+} ions at this stage is 0.555 mol L^{-1}.

(c) Calculate the minimum hydroxide ion concentration and hence the pH of the solution needed for precipitation to occur.

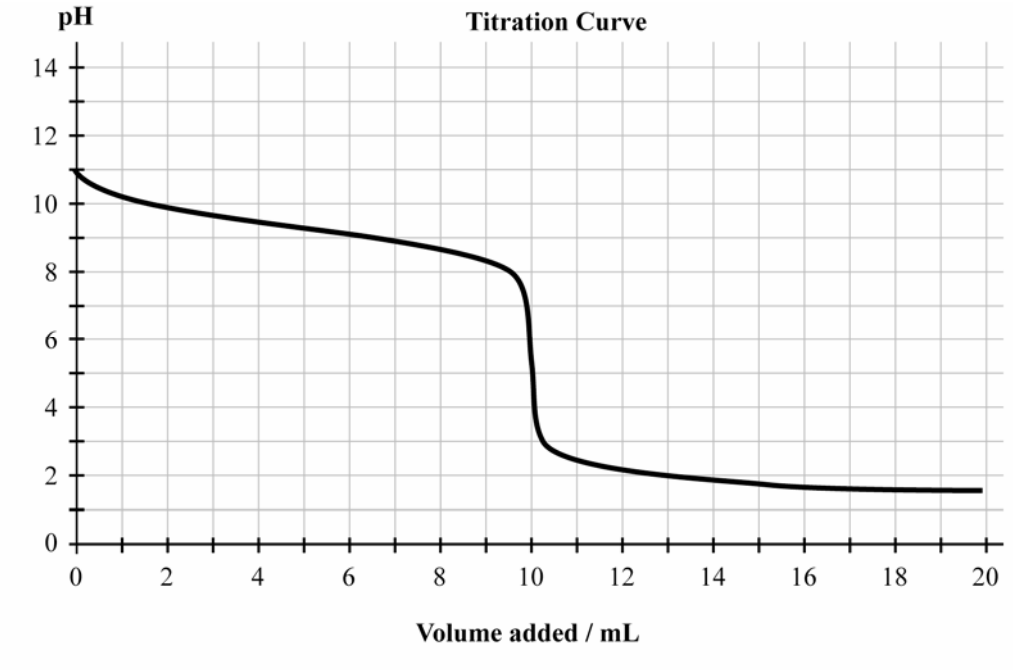
$$K_s\ (Mg(OH)_2) = 7.10 \times 10^{-12}$$

QUESTION THREE: TITRATION CURVES

The graph below shows the change in pH when 40.0 mL of 0.0500 mol L^{-1} aqueous NH_3 is titrated with 0.200 mol L^{-1} aqueous HCl.

The equation for the reaction occurring during the titration is:

$$NH_3(aq) + HCl(aq) \rightarrow NH_4Cl(aq)$$



(a) Use the curve to determine $pK_a(NH_4^+)$ and hence calculate $K_a(NH_4^+)$.

$pK_a(NH_4^+)$

$K_a(NH_4^+)$

(b) Explain why the pH at the equivalence point for this titration is less than 7. (Include an equation to support your answer.)

A NH_4^+/NH_3 buffer solution is prepared with a pH of 9.6.

(c) Use the graph to describe how this buffer solution could be made from 0.0500 mol L^{-1} NH_3 solution and 0.200 mol L^{-1} HCl solutions.

A second titration is carried out – this time 40.0 mL of 0.0500 mol L^{-1} NH_4Cl solution is titrated against 0.200 mol L^{-1} NaOH solution.

(d) Write an equation for the titration reaction.

(e) (i) Show that $[NH_3]$ at the equivalence point is 0.0400 mol L^{-1}.

(ii) Using $K_a(NH_4^+)$ determined in part (a) on the previous page, determine the pH at the equivalence point of the second titration.