

Chemistry 3.7, 2004

90700 Describe aqueous systems using equilibrium principles

Credits: Five

A periodic table is provided on Resource Sheet L3-CHEMR.

You should answer ALL the questions in this booklet.

Show working for all calculations.

Achievement Criteria			<i>For Assessor's use only</i>
Achievement	Achievement with Merit	Achievement with Excellence	
Describe aqueous systems using equilibrium principles.	Apply information about aqueous systems using equilibrium principles.	Analyse and interpret information about aqueous systems using equilibrium principles.	
Overall Level of Performance			

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

Question One: Precipitates

Show, by calculation, that a precipitate forms when 50.0 mL of 0.100 mol L⁻¹ KCl(aq) and 50.0 mL of 0.0200 mol L⁻¹ AgNO₃(aq) are mixed.

$$K_s(\text{AgCl}) = 1.56 \times 10^{-10}$$

Question Two: Lead bromide and solubility

A 50.0 mL sample of a saturated aqueous solution of lead bromide, PbBr₂, was evaporated to dryness. 0.422 g of solid PbBr₂ was obtained.

a i Write the equation for the equilibrium present in a saturated solution of lead bromide.

ii Complete the expression for $K_s(\text{PbBr}_2)$.

$$K_s(\text{PbBr}_2) =$$

b Calculate the value of $K_s(\text{PbBr}_2)$.

$$M(\text{PbBr}_2) = 367 \text{ g mol}^{-1}$$

Question Three: The nature of solids

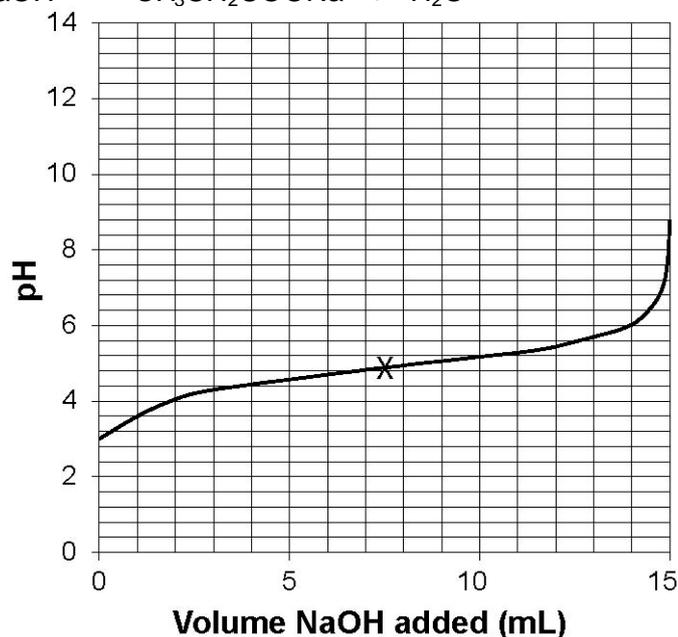
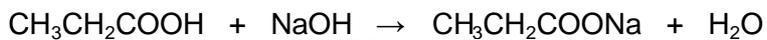
Solutions of ionic salts may be acidic, alkaline or neutral depending on the species present in the solution.

Discuss the above statement using, as examples, the salts sodium chloride, NaCl, sodium hypochlorite, NaOCl, and ammonium chloride, NH₄Cl. Include all appropriate equations.

NOTE: Solutions of HCl and HOCl are both acidic but HOCl is a weaker acid.

Question Four: Titration of propanoic acid

The graph below is part of a titration curve and shows the change in pH as an aqueous solution of 0.125 mol L^{-1} NaOH is added to 25.0 mL of propanoic acid solution ($\text{CH}_3\text{CH}_2\text{COOH}$).



- Calculate** the concentration of the propanoic acid solution.
- What is the pK_a of propanoic acid?
- Calculate the pH of the solution at the equivalence point.
- Compare the relative concentration of all species present in the mixture at the point marked X on the titration curve shown above. No calculations are expected.

- e The table below contains information about some pH indicators.

Name	Colour (low pH to high pH)	pH range	pK_a
Methyl orange	Red – yellow	3.1 – 4.4	3.7
Bromocresol green	Yellow – purple	5.2 – 6.8	6.3
Bromothymol blue	Yellow – blue	6.0 – 7.6	7.0
Cresol red	Yellow – red	7.2 – 8.8	8.3
Thymolphthalein	Colourless – blue	9.2 – 10.5	9.7

From this list identify any indicator(s) that could be used to determine the equivalence point in this titration. Give reasons for the suitability of the selected indicator(s).

Question Five: Buffer solutions

A buffer solution can be prepared by dissolving solid ammonium chloride, NH_4Cl , in a solution of aqueous ammonia, NH_3 .

$$pK_a(NH_4^+) = 9.24 \quad K_a(NH_4^+) = 5.75 \times 10^{-10}$$

- a Calculate the mass of solid ammonium chloride that must be added to one litre of 0.05 mol L^{-1} ammonia to produce a buffer of pH 8.80.

$$M(NH_4Cl) = 53.5 \text{ g mol}^{-1}$$

- b Discuss how the pH **and** the effectiveness of this buffer vary depending on the relative concentrations of NH_3 and NH_4^+ in the solution.