REVIEW QUESTIONS

Chapter 9: Aqueous Solutions

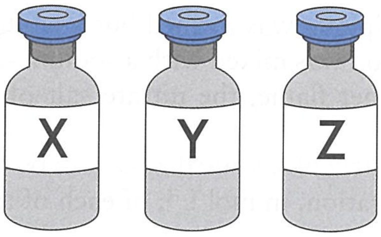
1. A student was given a clear, colourless solution of NaCl. Explain what steps the student could take to determine if the solution was unsaturated, saturated or supersaturated.

2. Complete the following table by placing the substances listed into the correct cells.
You may need to refer to your solubility tables as well as Chapter 5 on bonding.

$NaCl$, HCl , Zn , SiO_2 , Fe , CH_3COOH , Na_2CO_3 , $C_{12}H_{22}O_{11}$ (sugar) , $Cu(NO_3)_2$, Au , olive oil , ammonia , kerosene , ethanol , diamond , petrol

	SUBSTANCE TYPE			
	Covalent Network	Covalent Molecular	Metallic	Ionic
SOLUBLE				
INSOLUBLE				

3. A student was given three bottles labelled X, Y and Z and was told that the bottles contained 0.1 mol L^{-1} ethanoic acid, 0.1 mol L^{-1} sulfuric acid or distilled water.



(a) What single test (no chemical reaction involved) could be used to identify the chemical in each bottle?

(b) Explain how the test results indicate which liquid is in each bottle.

4. Write equations to show what happens when each of the substances listed is dissolved in water:

(a) hydrogen chloride gas
(b) magnesium sulfate
(c) ethanoic acid (CH_3COOH)
(d) phosphoric acid
(e) sodium hydroxide
(f) ammonia gas
(g) potassium iodide
(h) aluminium sulfate

5. It has been observed that ammonia and ethanoic acid solutions are weak conductors of electricity whereas the solution formed when they are mixed is a good conductor. Explain these observations.

6. A 50 000 litre swimming pool requires a "total alkalinity" of between 120 and 160 ppm. The "total alkalinity" is managed by adding Na_2CO_3 to the water. Would adding 5.50 kg of Na_2CO_3 be enough to create a "total alkalinity" reading within the accepted range if the initial reading was 0 ppm? (Assuming that 1.0 L of the pool water weighs 1.0 kg.)

7. The nitrogen (N) content of a sample of water from the Swan River was found to be 1.0 mg L^{-1}. Convert this to a concentration measured in mol L^{-1}.

8. A sample of river water was found to have a salt (NaCl) content of 20.0 g L^{-1} while a sample of lake water was found to have a salt content of 0.500 mol L^{-1}. How much salt could be extracted from 750 L of each type of water?

9. Write ionic equations for the following reactions. If no precipitate forms write "no reaction". Assume that all solutions are 0.1 mol L^{-1}.

   (a) $AgNO_{3(aq)} + NaBr_{(aq)}$
   (b) $FeCl_{3(aq)} + NaOH_{(aq)}$
   (c) $Na_3PO_{4(aq)} + Cu(NO_3)_{2(aq)}$
   (d) $Cr_2(SO_4)_{3(aq)} + (NH_4)_2CO_{3(aq)}$
   (e) $Pb(NO_3)_{2(aq)} + KI_{(aq)}$
   (f) $SrCl_{2(aq)} + Fe_2(SO_4)_{3(aq)}$

10. Name the metal ions that responsible for the following observations:

   (a) Solutions of this metal ion did not from precipates when mixed with solutions of potassium carbonate, potassium sulfate and potassium hydroxide. When a the salt of this ion was placed in a bunsen burner flame an yellow colour was produced.

   (b) A blue solution produced a green precipitate when mixed with a potassium carbonate solution.

   (c) When a nitrate solution of this metal ion was mixed with a sodium chloride solution no precipitate was formed but a white precipitate was form when the nitrate solution was mixed with a sodium sulfate solution. When placed in a bunsen burner flame, the nitrate salt of this metal produced a pale green flame.

11. Calculate the concentration, in mol L^{-1}, of each of the following solutions:

   (a) 15.2 g of sodium carbonate was dissolved in enough water to make 375 mL of solution.

   (b) 2.50 kg of calcium chloride was added to a swimming pool that contained 45.0 m^3 of water.

   (c) 9.47 g of hydrogen chloride was dissolved in enough water to create 0.250 L of solution.

12. A 0.150 kg sample of sludge from the bottom of a river was found to contain 1.026×10^{-4} g of mercury. Determine the concentration of the mercury in the sludge in parts per million.

13. The label on a brand of toothpaste states that it contains 0.32% w/w sodium fluoride. What mass of sodium fluoride is contained in 0.750 g of toothpaste?

14. Water is essential to life and provides a medium for many chemical reactions. Since it is a good solvent, the water around us in natural aquatic systems is not pure. It contains varying amounts of dissolved substances. For each of the following substances explain their importance or significance if dissolved in groundwater. The first one is done for you.

(i) Dissolved carbon dioxide.

Means that rainwater is slightly acidic – dissolves underground limestone – causes cave formation. Also, dissolved CO_2 *allows photosynthesis in aquatic systems.*

(ii) Dissolved oxygen.

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(iii) Dissolved nitrogen and phosphorus compounds.

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(iv) Dissolved salts due to rising water table.

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(v) Dissolved salts of heavy metals such as mercury.

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(vi) Excess dissolved nutrients from waste water, detergents and fertilisers.

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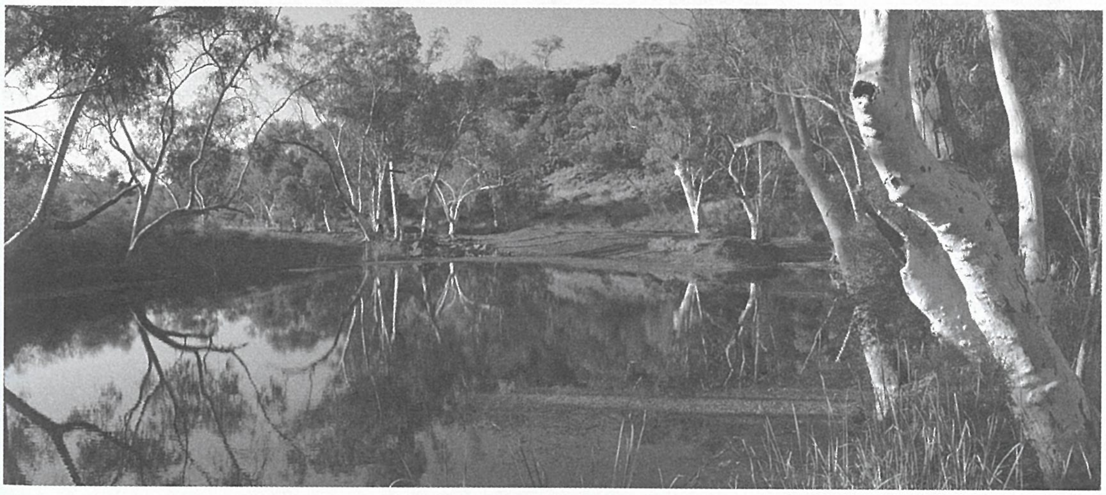


FOR THE EXPERTS

15. Many Australian soils are lacking in nutrients such as phosphorus and nitrogen. Gardeners and farmers often apply fertilisers to improve the soil quality.

(a) The label on a container of soluble garden fertiliser stated that it had a 4.5% phosphorus content.

Determine the P concentration (in mol L^{-1}) produced when two scoopfuls, or 15 g, of this fertiliser was dissolved in 9.0 L of water.

(b) Superphosphate is regularly used on farms to improve soils before planting legumes. Superphosphate is a mixture of the soluble compounds calcium dihydrogenphosphate and calcium sulfate dihydrate.

(i) Write the equation showing what occurs when superphosphate is dissolved in water.

(ii) A manufacturer claims that their superphosphate is 8.8% P, of which 95% is useable by plants.

Calculate the amount of phosphorus that would be made available to plants if a farmer spread 10 tonne of superphosphate onto the paddocks (1 tonne = 1000 kg).

9.22

	K^+	Pb^{2+}	NH_4^+	Ba^{2+}	Ag^+
Cl^-	-	$PbCl_{2(s)}$ white	-	-	AgCl(s) white
I^-	-	$PbI_{2(s)}$ yellow	-	-	AgI(s) yellow
SO_4^{2-}	-	$PbSO_{4(s)}$ white	-	$BaSO_{4(s)}$ white	$Ag_2SO_{4(s)}$ white
CO_3^{2-}	-	$PbCO_{3(s)}$ white	-	$BaCO_{3(s)}$ white	$Ag_2CO_{3(s)}$ white

9.23

$CaO_{(s)} + H_2O_{(l)} \rightarrow Ca^{2+}{(aq)} + 2\ OH^-{(aq)}$

Cadmium ions in the water will form the insoluble $Cd(OH)_2$ precipitate when lime is added.

$Cd^{2+}{(aq)} + 2\ OH^-{(aq)} \rightarrow Cd(OH)_{2(s)}$

9.24

(a) *Strontium*, $Sr^{2+}{(aq)} + SO_4^{2-}{(aq)} \rightarrow SrSO_{4(aq)}$

(b) *Calcium may cause a similar set of results.* $Ca^{2+}{(aq)}$ *is sparingly soluble with sulfate ions and as only a small amount of dilute sodium sulfate was added the calcium ions may have remained soluble.*

Review Questions

1. *Any undissolved solid indicates a saturated solution. If otherwise, it may be supersaturated (any addition of NaCl would cause crystallisation) or unsaturated (any additional NaCl would dissolve).*

2.

	SUBSTANCE TYPE			
	Covalent Network	Covalent Molecular	Metallic	Ionic
Soluble	–	HCl, NH_3, CH_3COOH, $C_{12}H_{22}O_{11}$, ethanol	–	NaCl, Na_2CO_3, $Cu(NO_3)_2$
Insoluble	SiO_2, diamond	olive oil, kerosene, petrol	Zn, Fe, Au	–

3.

(a) *A conductivity test.*

(b) *If no conduction – water.*
If minor conduction – ethanoic acid.
If good conduction – sulfuric acid.

4.

(a) $HCl_{(g)} \rightarrow HCl_{(aq)} \rightarrow H^+{(aq)} + Cl^-{(aq)}$

(b) $MgSO_{4(s)} \rightarrow Mg^{2+}{(aq)} + SO_4^{2-}{(aq)}$

(c) $CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-{(aq)} + H^+{(aq)}$

(d) $H_3PO_{4(aq)} \rightleftharpoons H_2PO_4^-{(aq)} + H^+{(aq)}$

(e) $NaOH_{(s)} \rightarrow Na^+{(aq)} + OH^-{(aq)}$

(f) $NH_{3(g)} + H_2O_{(l)} \rightleftharpoons NH_4^+{(aq)} + OH^-{(aq)}$

(g) $KI_{(s)} \rightarrow K^+{(aq)} + I^-{(aq)}$

(h) $Al_2(SO_4)_{3(s)} \rightarrow 2Al^{3+}{(aq)} + 3SO_4^{2-}{(aq)}$

5. *Both ammonia and ethanoic acid solutions are weak conductors of electricity because they only slightly ionise in aqueous solution. Hence there are few ions to transfer the current. When they are combined, however, ammonium ethanoate is produced. This salt is highly soluble and a good electrolyte.*

$NH_{3(aq)} + CH_3COOH_{(aq)} \rightarrow NH_4CH_3COO_{(aq)}$ *and*
$NH_4CH_3COO_{(aq)} \rightarrow NH_4^+{(aq)} + CH_3COO^-{(aq)}$

6. $ppm = \dfrac{{}^*mg\ of\ solute}{kg\ of\ solution}$

$= \dfrac{(5.50)(1{,}000{,}000)}{50{,}000}$

$= 110\ ppm$

*mg = milligrams
$= 1.0 \times 10^{-3}$ *grams*
$= 1.0 \times 10^{-6}$ *kg*

Just under the accepted range.

7. $c(N) = 1.0\ mg\ L^{-1}$

$= \dfrac{1.0 \times 10^{-3} mol\ L^{-1}}{14.0}$

$= 7.14 \times 10^{-5} mol\ L^{-1}$

8. *river water conc (salt)* $= 20.0\ g\ L^{-1}$
$\therefore$ *mass in 750 L* $= (20.0)(750)$
$= 1.5 \times 10^4 g$ *(15 kg)*
lake water conc (salt) $= 0.50\ mol\ L^{-1}$
$\therefore$ *n (salt) in 750 L* $= (0.50)(750) = 375\ mol$
$\therefore$ *m (salt) in 750 L* $= (375)(58.44) =$
$2.19 \times 10^4 g$ *(21.9 kg)*

9.

(a) $Ag^+{(aq)} + Br^-{(aq)} \rightarrow AgBr_{(s)}$

(b) $Fe^{3+}{(aq)} + 3OH^-{(aq)} \rightarrow Fe(OH)_{3(s)}$

(c) $3Cu^{2+}{(aq)} + 2PO_4^{3-}{(aq)} \rightarrow Cu_3(PO_4)_{2(s)}$

(d) $2Cr^{3+}{(aq)} + 3CO_3^{2-}{(aq)} \rightarrow Cr_2(CO_3)_{3(s)}$

(e) $Pb^{2+}{(aq)} + 2I^-{(aq)} \rightarrow PbI_{2(s)}$

(f) $Sr^{2+}{(aq)} + SO_4^{2-}{(aq)} \rightarrow SrSO_{4(s)}$

10. (a) *Sodium ions*
(b) Cu^{2+} *or copper (II) ions*
(c) *Barium ions*

11.

(a) $n(Na_2CO_3) = m/M$
$= 15.2/(45.98+12.01+48.00) = 0.143$
$c(Na_2CO_3) = n/V = 0.143/0.375 = 0.382\ mol\ L^{-1}$

(b) $n(CaCl_2) = m/M = 2500/(40.08 + 70.90) = 22.53$
$c(CaCl_2) = n/V = 22.53/45000 = 5.01 \times 10^{-4}\ mol\ L^{-1}$

(c) $n(HCl) = m/M = 9.47/(1.008 + 35.45) = 0.260$
$c(HCl) = n/V = 0.260/0.250 = 1.04\ mol\ L^{-1}$

12. $ppm = m(Hg)$ *in mg/m (sludge) in kg* $= 0.1026/0.150 = 0.684\ ppm$

13. *m(NaF) in toothpaste* = $0.750 \times 0.32/100 = 2.40 \times 10^{-3}$ g

14.
(i) *Done in text.*
(ii) *Dissolved oxygen is essential to aquatic plants and animals for respiration.*
(iii) *Dissolved compounds of nitrogen (usually nitrates) and phosphorus (phosphates) are essential nutrients to plant growth. Excess nutrients however, can cause eutrophication.*
(iv) *Increased salinity of soil reduces their suitability for farming. Rivers and water supplies become more salty.*
(v) *Dissolved salts of heavy metals (mercury, lead, chromium, cadmium, etc) are toxic if they accumulate in the body to significant amounts. For humans, fish can be such a source.*
(vi) *Excess dissolved nutrients stimulate plant growth such as algal bloom. The eventual bacterial decay of the algae depletes the oxygen in the water. This causes animal life to suffer.*

For the Experts

15.

(a) $n = \frac{m}{M} = \frac{15.0}{30.97} \times \frac{4.5}{100} = 0.0218$ mol

$\therefore c = \frac{n}{V} = \frac{0.0218}{9.0\ L} = 2.42 \times 10^{-3}$ mol L^{-1}

(b)
(i) $Ca(H_2PO_4)_{2\,(aq)} \rightarrow Ca^{2+}(aq) + 2H_2PO_4^-(aq)$
$CaSO_4 \cdot 2H_2O_{(aq)} \rightarrow Ca^{2+}(aq) + SO_4^{2-}(aq) + 2H_2O_{(l)}$
(ii) mass of P $= \frac{8.8}{100} \times \frac{95}{100} \times 10{,}000$ kg

= 836 kg of P

CHP 10: ACIDS AND BASES

Chapter Questions

10.1
(a)

ACIDIC SOLUTIONS	BASIC SOLUTIONS
$[H^+] > [OH^-]$	$[H^+] < [OH^-]$
$[H^+] > 1.00 \times 10^{-7}$ mol L^{-1}	$[H^+] < 1.00 \times 10^{-7}$ mol L^{-1}
$[OH^-] < 1.00 \times 10^{-7}$ mol L^{-1}	$[OH^-] > 1.00 \times 10^{-7}$ mol L^{-1}

10.2
(a) $HNO_3(aq) \rightarrow H^+(aq) + NO_3^-(aq)$, acidic
(b) $HClO(aq) \rightarrow H^+(aq) + ClO^-(aq)$, acidic
(c) $KOH(s) \rightarrow K^+(aq) + OH^-(aq)$, basic
(d) $Ba(OH)_2(s) \rightarrow Ba^{2+}(aq) + 2OH^-(aq)$, basic

10.3

	Acid	Base
(a)	CH_3COOH	H_2O
(b)	HSO_4^-	CO_3^{2-}
(c)	H_3PO_4	NaOH
(d)	HCl	NH_3
(e)	H_2O	PO_4^{3-}

10.4
Acid: $H_2O(l) + HCO_3^-(aq) \rightleftharpoons H_2CO_3(aq) + OH^-(aq)$
Base: $H_2O(l) + H_2PO_4^-(aq) \rightleftharpoons H_3O^+(aq) + HPO_4^{2-}(aq)$

10.5
$Ca(OH)_2(s) \rightarrow Ca^{2+}(aq) + 2OH^-(aq)$
The production of OH^- *ions will make the soil basic.*

10.6
$SO_2(g) + H_2O(l)\ (\rightarrow H_2SO_3(aq)) \rightleftharpoons H^+(aq) + HSO_3^-(aq)$
$SO_3(g) + H_2O(l)\ (\rightarrow H_2SO_4(aq)) \rightarrow H^+(aq) + HSO_4^-(aq)$

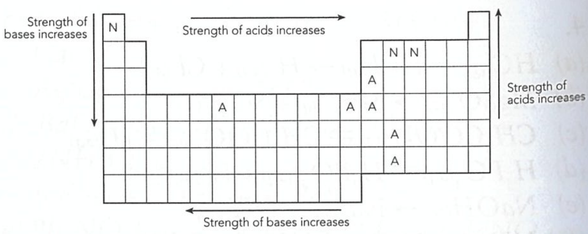
10.7
(a) *Ethanoic acid is a weak acid, only a small % of* CH_3COOH *molecules will ionise to form* H^+ *ions. Therefore the* $[H^+]$ *will be considerably lower than the* $[CH_3COOH]$.
(b) $pH = -\log[H^+] = -\log(4.16 \times 10^{-4}) = 3.38$

10.8
(a) $[H^+] = 1.00 \times 10^{-9}$ mol L^{-1}
(b) $[H^+] < 1.00 \times 10^{-7}$ mol L^{-1}, *solution is basic*

10.9
(a) $HBr(aq) \rightarrow H^+(aq) + Br^-(aq)$
(b) $H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-} \rightleftharpoons H^+ + PO_4^{3-}$
(c) $SO_2 + H_2O \rightarrow H_2SO_3 \rightleftharpoons H^+ + HSO_3^-$
(d) $SO_3 + H_2O \rightarrow H_2SO_4 \rightarrow H^+ + HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$

10.10
(a) $Na_2O(s) + H_2O(l) \rightarrow 2Na^+(aq) + 2OH^-(aq)$
(b) $NH_3(g) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$
(c) $PO_4^{3-}(aq) + H_2O(l) \rightleftharpoons HPO_4^{2-}(aq) + OH^-(aq)$
(d) $KHCO_3(s) + H_2O(l) \rightarrow K^+(aq) + HCO_3^-(aq) + H_2O \rightleftharpoons K^+(aq) + H_2CO_3(aq) + OH^-(aq)$

10.11



A = amphoteric
N = neutral (H_2O, CO, NO *and* N_2O)
10.12