Applecross Senior High School

AECHE 2017
Aqueous Solutions and Acidity
Test

Time allowed: 55 minutes

Name: Marking Key

Section	Mark Scored
Part 1: Multiple Choice Questions	/14
Part 2: Short Answer Questions	/22
Part 3: Extended Answer Question	/14
Total	/50 = %

Part 1: Multiple Choice Questions [14 marks]

1. When a teaspoon of sugar is added to a beaker containing a saturated sugar solution, which one of the following would be observed?

   (a) All the added sugar would dissolve.
   (b) The solution would become a little sweeter.
   (c) Only some of the added sugar would dissolve.
   (d) More sugar crystals than before would appear in the beaker. – additional sugar = more crystals.

2. Which one of the following sets of 0.1 mol L^{-1} solutions can be mixed to make a green solution **without** a precipitate?

   (a) sodium iodide, nickel chloride, silver nitrate – AgCl, AgI ppt formed.
   (b) chromium(III) sulfate, ammonium carbonate, iron(II) chloride – $FeCO_3$, $CrCO_3$ ppt formed.
   (c) potassium sulfate, sodium carbonate, sodium phosphate – no green soln, no ppt's
   (d) magnesium sulfate, potassium nitrate, nickel ethanoate – green + no ppt's

3. Which one of the following lists classifies all of the substances correctly?

	pure substances	homogeneous mixtures	heterogeneous mixtures
(a)	copper sulfate ✓	steel ✓	the ocean ✓
(b)	air ✗	cordial ✓	sugar solution ✗
(c)	tap water ✗	dissolved cooking salt ✓	carbon dioxide ✗
(d)	distilled water ✓	diamond ✗	iron ore ✓

4. Which one of the 0.02 mol L^{-1} solutions below will have the **highest** pH?

↓ weakest acid.

(a) HCl strong A
(b) H_2SO_4 strong A
(c) HNO_3 strong A
(d) CH_3COOH weak A

5. Which one of the following combinations of species shows **all** the products of the reaction of hydrochloric acid and zinc metal which have **reacted completely** with one another?

(a) $ZnCl_{2(s)} + H_2O_{(aq)} + H_{2(g)}$
(b) $ZnCl_{2(s)} + H_{2(g)}$ ← doesn't react.
(c) $Zn^{2+}_{(aq)} + 2Cl^-_{(aq)} + H_{2(g)}$
(d) $Zn^{2+}_{(aq)} + H_{2(g)}$

6. The concentration of vitamin C in a particular brand of orange juice is 35 mg per 100 mL. Which one of the following is the correct mass of vitamin C contained in a 2.5 L bottle of orange juice?

(a) 87.5 mg
(b) 875 mg
(c) 8.75 g
(d) 875 g

35 mg in 100 mL.
350 mg in 1000 mL (1L).
mass vit C = 2.5 × 350
= 875 mg.

7. Which one of the following 0.100 mol L^{-1} aqueous solution combinations will form at least one precipitate?

(a) sodium chloride, barium nitrate, potassium hydroxide no ppt's
(b) tin(II) nitrate, caesium nitrate, sodium sulfate no ppt is
(c) copper(II) sulfate, sodium ethanoate, hydrochloric acid no ppt's
(d) barium hydroxide, sodium chloride, iron(II) sulfate $Pb(OH)_2$ formed.

8. Which of the following substances is a **weak base**?

(a) sodium hydroxide ← Na^+ OH^- strong base
(b) ammonia NH_3 weak base.
(c) ammonium nitrate NH_4^+ – weak acid
(d) hydrochloric acid H^+ Cl^- – strong acid.

9. Which of the following sets, lists all the species present in a 1.5 M bottle of sulfuric acid?

(a) H^+, H_2O, SO_4^{2-}, HSO_4^-
(b) H^+, H_2O (SO_4^{2-}, HSO_4^-).
(c) H^+, H_2O, SO_4^{2-}, (HSO_4^-)
(d) H^+ ✓, H_2O ✓, SO_4^{2-} ✓, HSO_4^- ✓, H_2SO_4 ✗

10. When 4.59 g of zinc acetate, $Zn(CH_3COO)_2$, is dissolved in enough water to make 1.00 L of solution, the concentrations of zinc and acetate ions are, respectively,

Zn^{2+} CH_3COO^-
(a) 0.0250 mol L^{-1} ✓ and 0.0250 mol L^{-1} ✗
(b) 0.0250 mol L^{-1} ✓ and 0.0500 mol L^{-1} ✓
(c) 0.0369 mol L^{-1} ✗ and 0.0738 mol L^{-1} ✗
(d) 0.0250 mol L^{-1} ✓ and 0.0125 mol L^{-1} ✗

$M_{Zn(CH_3COO)_2}$
$= 65.38 + (4 \times 12.01) + (6 \times 1.008) + (4 \times 16)$
$= 183.468$

$n_{Zn(CH_3COO)_2} = \frac{4.59}{183.468} = 2.50 \times 10^{-2}$

$n_{Zn^{2+}} = n_{Zn(CH_3COO)_2} = 0.025\,mol$
$n_{CH_3COO^-} = 2n_{Zn(CH_3COO)_2} = 0.050\,mol$

$c_{Zn^{2+}} = \frac{2.50 \times 10^{-2}}{1.00} = 2.50 \times 10^{-2}\,mol\,L^{-1}$.
$c_{CH_3COO^-} = \frac{0.050}{1.00} = 5.00 \times 10^{-2}\,mol\,L^{-1}$.

11. Which one of the following characteristics does **not** apply to solutions?

(a) They are homogeneous mixtures. ✓
(b) They contain two or more substances. ✓
(c) They have uniform composition. ✓
(d) They always contain a solid that has dissolved in a liquid. ✗

12. An ammonia solution that is 8 mol L^{-1} is best described as a

(a) concentrated weak base.
(b) dilute weak base.
(c) concentrated strong base.
(d) dilute strong base.

13. Which one of the following has the greatest hydrogen ion concentration?

(a) 0.1 mol L^{-1} $HCl_{(aq)}$ → $H^+ + Cl^-$
(b) 0.1 mol L^{-1} $CH_3COOH_{(aq)}$ → $CH_3COO^- + H^+$
(c) 0.1 mol L^{-1} $H_2SO_{4(aq)}$ → $SO_4^{2-} + 2H^+$
(d) 0.1 mol L^{-1} $HNO_{3(aq)}$ → $H^+ + NO_3^-$

14. Which one of the following sets of pH **best** corresponds to 0.1 mol L^{-1} solutions of the stated substances?

	strong acid **nitric acid**	weak base **ammonia**	strong base **sodium hydroxide**
(a)	1 ✓	9 ✓	13 ✓
(b)	7 ✗	13 ✗	9 ✗
(c)	4 ✗	7 ✗	14 ✓
(d)	1 ✓	13 ✗	9 ✗

Part 2: Short Answer Questions [22 marks]

Question 1 (9 marks)

(i) Describe the observations that you would make for each of the following reactions.
(ii) Write a balanced chemical equation for each reaction. Show only those species that take part in the reaction and use the appropriate state symbols. If no reaction occurs write, 'no reaction'.

(a) Solid potassium carbonate is dropped into a container of dilute sulfuric acid.
Observations:

solid dissolves, bubbles (effervescence) produced (1)

Chemical equation:

$K_2CO_{3(s)} + 2H^+_{(aq)} \rightarrow CO_{2(g)} + 2K^+_{(aq)} + H_2O_{(l)}$ (2)

(b) Iron(III) sulfate solution is mixed with sodium carbonate solution.
Observations:

A pale brown ppt is formed. (1)

Chemical equation:

$2Fe^{3+}_{(aq)} + 3CO_3^{2-}_{(aq)} \rightarrow Fe_2(CO_3)_{3(s)}$ (2)

(c) Ammonia gas is bubbled through a dilute solution of nitric acid.
Observations:

bubbles dissolve in the solution. (1)

Chemical equation:

$NH_{3(g)} + H^+_{(aq)} \rightleftharpoons NH_4^+_{(aq)}$ (2)

Question 2 (5 marks)
Given a 0.0111 mol L^{-1} $Mg(NO_3)_2$ solution, calculate the concentration in g L^{-1} for each ion present.

In 1 L solution

$n_{Mg^{2+}} = 0.0111$ mol

$n_{NO_3^-} = 2 \times n_{Mg^{2+}} = 2 \times 0.0111 = 0.0222$ mol. } ①

$m_{Mg^{2+}} = nM$

$= 0.0111 \times 24.31$

$= 0.2698$ g. ①

$C_{Mg^{2+}} = \frac{m}{V}$

$= \frac{0.2698}{1.0}$

$= 2.70 \times 10^{-1}$ g L^{-1} ①

$m_{NO_3^-} = nM$

$= 0.0222 \times [14.01 + (3 \times 16.0)]$

$\approx 0.0222 \times 62.01$

$= 1.377$ g. ①

$C_{NO_3^-} = \frac{1.377}{1.0}$

$= 1.38 \times 10^{0}$ g L^{-1}. ①

Question 3 (5 marks)

Complete the table below by writing the formula of each of the compounds listed.

Name of Compound	Formula of Compound	Acid, Base or Neutral?
Ethanoic acid	CH_3COOH	Acid
Sulfuric acid	H_2SO_4	acid
Magnesium hydroxide	$Mg(OH)_2$	base
Sodium oxide	Na_2O	base
Potassium chloride	KCl	neutral.

Question 4 (3 marks)
The poisonous compound oxalic acid ($H_2C_2O_4$) is found in significant quantities in the leaves of the rhubarb plant, while its stalks contain only trace amounts, making them safe to eat. Oxalic acid is a polyprotic acid.

(a) Explain what is meant by the term 'polyprotic'. (1 mark)

A polyprotic acid produces two or more acid protons in solution.

(b) Complete the table below by giving appropriate formulae. (2 marks)

Substance	Example
A polyprotic acid (other than oxalic acid)	H_2SO_4, H_3PO_4 etc (any one)
A monoprotic acid	HCl, HNO_3 etc any one.

Part 3: Extended Answer Question [14 marks]

Vinegar is effectively a dilute solution of a weak acid.

(a) Vinegar is characterised as a dilute solution. What does 'dilute' mean in this case?

(1 marks)

Vinegar is dilute because it only contains a few particles of ethanoic acid (solute) in a large number of water particles (solvent).

(b) Ethanoic acid is characterised as a weak acid. What does 'weak' mean in this case?

(1 marks)

Ethanoic acid is a weak base because it only partially ionises in water.

An interesting thing you can do with household vinegar is to soften the shell of a boiled egg by leaving it to soak in vinegar overnight.

(c) The ingredient in eggshells that makes them hard is calcium carbonate, $CaCO_{3(s)}$. Write the equation for the reaction that occurs when vinegar, $CH_3COOH_{(aq)}$, and eggshells come in contact with each other.

(2 marks)

$$CaCO_{3(s)} + 2CH_3COOH_{(aq)} \rightarrow Ca^{2+}_{(aq)} + 2CH_3COO^-_{(aq)} + CO_{2(g)} + H_2O_{(\ell)}$$

(d) If each eggshell contains on average 4.00 g of calcium carbonate, what is the maximum number of eggs that can be softened by having all their calcium carbonate dissolved if they are immersed in one 2.00 L bottle of vinegar containing 4.5 $molL^{-1}$ ethanoic acid? Assume that 2.00 L of vinegar has a mass of 2.00 kg.

(5 marks)

$n_{CH_3COOH} = cV$

$= 4.5 \times 2.00$

$= 9.0\ mol$ (1)

$n_{CaCO_3} = \frac{1}{2} n_{CH_3COOH}$

$= \frac{1}{2} \times 9.0$

$= 4.5\ mol.$ (1)

$m_{CaCO_3} = nM$

$= 4.5 \times [40.08 + 12.01 + (3 \times 16)]$ (1)

$= 4.5 \times 100.09$

$= 450.405\ g.$ (1)

$\text{number of eggs} = \frac{450.405}{4.0}$

$= 112.6$

$= 112\ \text{eggs}.$ (1)

(e) The label on a 1.25 L bottle of vinegar states that it contains 25.0 g of ethanoic acid, $CH_3COOH(aq)$.

(i) Calculate the number of moles of ethanoic acid present in the full bottle of vinegar.

(2 marks)

$$n_{CH_3COOH} = \frac{m}{M}$$

$$= \frac{25.0}{[(2 \times 12.01) + (4 \times 1.008) + (2 \times 16.0)]} \quad (1)$$

$$= \frac{25.0}{60.052}$$

$$= 4.16 \times 10^{-1} \text{ mol}. \quad (1)$$

(ii) Determine the concentration of ethanoic acid in mol L^{-1}.

(1 mark)

$$C_{CH_3COOH} = \frac{n}{V}$$

$$= \frac{4.16 \times 10^{-1}}{1.25}$$

$$= 3.33 \times 10^{-1} \text{ mol } L^{-1}. \quad (1)$$

(iii) Determine the concentration of ethanoic acid in g L^{-1}.

(1 mark)

$$C_{CH_3COOH} = \frac{m}{V}$$

$$= \frac{25.0}{1.25}$$

$$= 20.0 \text{ g } L^{-1}$$

(iv) 2.0 L of this vinegar will soften fewer eggs than the vinegar in Part (b). Explain why.

(1 mark)

this vinegar will soften fewer eggs because it contains less H^+ ions (less moles of acid). (1).