YEAR 12 CHEMISTRY 3A/3BCHE
TOPIC TEST: Solutions, Acids & Bases

NAME: ....

PART 1: Multiple Choice

Answer **ALL** questions in Part 1 on the Separate Multiple Choice Answer Sheet provided.
This part carries 15 marks.

1. Which of the following possibilities describes the pH of a solution of the following compounds dissolved in distilled water?

	Sodium nitrate	Potassium ethanoate	Sodium Chloride	Calcium Oxide
a)	Less than 7	Greater than 7	Equals 7	Greater than 7
b)	Equals 7	Equals 7	Less than 7	Greater than 7
c)	Less than 7	Equals 7	Less than 7	Equals 7
d)	Equals 7	Greater than 7	Equals 7	Greater than 7

to confirm

2. In which of the following reactions is water acting as a base?

a) $Fe^{3+}(aq) + 6 H_2O(l) \rightarrow Fe(H_2O)_6^{3+}(aq)$

b) $H_2SO_4(l) + H_2O(l) \rightarrow HSO_4^-(aq) + H_3O^+(aq)$

c) $NH_3(g) + H_2O(l) \rightarrow NH_4^+(aq) + OH^-(aq)$

d) $Na_2O(s) + H_2O(l) \rightarrow 2NaOH$

3. Consider the following reaction :

$HCN(aq) + NH_3(aq) \iff CN^-(aq) + NH_4^+(aq)$

Which of the species in this equilibrium mixture are *acting as acids?* H^+ donors

a) $HCN(aq)$ and $NH_4^+(aq)$

b) $NH_3(aq)$ and $CN^-(aq)$

c) $HCN(aq)$ and $CN^-(aq)$

d) $NH_3(aq)$ and $NH_4^+(aq)$

4. The pH of an aqueous solution registers 12.0 on a pH meter. Which of the following solutions could be its identity?

a) 0.0010M KOH

b) 0.0500M NaOH

c) 0.0010M HCl

d) 0.0050M Ca(OH)$_2$

5. Which of the following oxides dissolves in water to give a *strongly acidic* solution?

   a) sulfur trioxide
   b) sodium oxide
   c) aluminium oxide
   d) barium oxide

   (handwritten: non-metal oxides)
   (handwritten answer: A)

6. Solid sodium hydrogen carbonate is added to deionised water at pH 7.00. Which of the following statements explains what then occurs?

   a) The pH decreases due to a reaction between HCO_3^- ions with water.
   b) The pH decreases due to a reaction between Na^+ ions with water.
   c) The pH increases due to a reaction between HCO_3^- ions with water.
   d) The pH increases due to a reaction between Na^+ ions with water.

   (handwritten: $HCO_3^- + H_2O \rightarrow H_2CO_3 + OH^-$)
   (handwritten answer: C)

7. A 0.200M ammonia solution (NH_3) is just 5.0% ionized. What is the pH of the solution?

   a) 0.70
   b) 2.0
   c) 12.0 *(circled)*
   d) 13.3

   (handwritten: $0.2 \times 0.05 = 10 \times 10^{-3} = 0.01 M$)

8. A few mL of water are added to 1.0 L of pure ethanoic acid. The resulting solution is:

   a) a concentrated solution of a weak acid.
   b) a dilute solution of a weak acid.
   c) a concentrated solution of a strong acid.
   d) a dilute solution of a strong acid.
   e) acidic with a pH greater than 7.

   (handwritten answer: A)

9. Which of the following best describes a weak acid?

   a) A weak acid has $[H^+]$ less than 10^{-3} M.
   b) A weak acid is a concentrated acid that has been diluted.
   c) A weak acid is one that undergoes limited ionization in solution.
   d) A weak acid is used as a buffer, strong acids cannot be used.

   (handwritten answer: C)

10. When the indicator Cresyl Blue is used it shows these results for high pH solutions :

pH	Colour with Cresyl Blue
10.0	blue
11.0	green
12.0	yellow
13.0	yellow

When 2 unknown solutions are tested with Cresyl Blue they give the following results:

Unknown solution	Colour with Cresyl Blue
X	Yellow
Y	Blue

Which of the following statements are supported by these observations?

   a) The pH of X is 12.0, and the pH of Y is 10.
   b) The pH of X is between 12.0 and 13.0, and the pH of Y is 10.
   c) The pH of X is between 12.0 and 13.0, and the pH of Y is 10 or less.   *(handwritten: Assume ×2)*
   d) The pH of X is 12.0 or more, and the pH of Y is 10 or less.   *(handwritten: Assume ×2)*

   (handwritten answer: D)

11. A 0.1 M HNO_3 solution has $[H^+] = 0.1$ M, whereas a 0.1 M CH_3COOH solution has $[H^+] = 0.003$ M. The best explanation for this difference is that:

   a) CH_3COOH molecules ionizes more than HNO_3 molecules. ✗
   b) HNO_3 is an ionic substance whereas CH_3COOH is molecular covalent. ✗
   c) Each HNO_3 molecule ionizes completely, but each CH_3COOH only partially ionizes. ✗
   d) HNO_3 donates protons to form H_3O^+(aq) in water more readily than CH_3COOH does.

   (handwritten: individual molecules ionize or don't, no in-betweens)
   (handwritten answer: D)

12. Which of the following statements concerning the solubility of a gas in a liquid is FALSE ?

   a) The energy of a gas is lower when it is dissolved in a liquid.
   b) Warming a saturated solution of a gas dissolved in a liquids causes bubbles of gas to appear on the sides of the container.
   c) The amount of gas which dissolves in water increases as the temperature increases. ✗
   d) Fish and other aquatic life depend on the oxygen dissolved in sea water.

   (handwritten answer: C)

PART 2:   Seven short answer and calculation questions. Write your answers using blue or black pen in the spaces provided. This part is worth a total of 40 marks.

1.   Write **balanced ionic** equations and give observations for the reactions that occur between the following reactants. Also write the observation that would occur as the reaction proceeded.

(a)   Cobalt (II) hydrogen carbonate (solid) is added to 1 M hydrochloric acid solution.

Equation: $Co(HCO_3)_2 + 2H^+ \rightarrow Co^{2+} + 2H_2O + 2CO_2$ [2 marks]
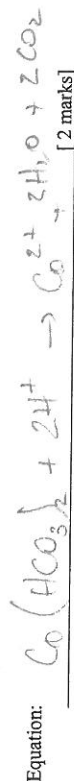
Observation: c'less soln added to pink solid produces pink soln and c'less, o'less gas   [1 mark]

(b)   Solid ammonium nitrate is mixed with solid calcium hydroxide powder and heated gently.

Equation: $2NH_4NO_3 + Ca(OH)_2 \rightarrow Ca^{2+} + 2NO_3^- + 2NH_3 + 2H_2O$ [2 marks]
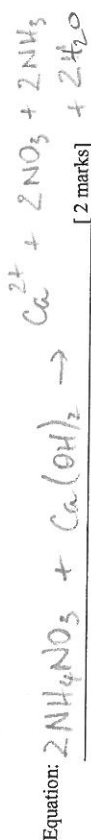
Observation: two white solids produce c'less soln and c'less, pungent gas   [1 mark]

(c)   A small piece of potassium metal is placed in a beaker containing dilute phosphoric acid. weak

Equation: $6K + 2H_3PO_4 \rightarrow 6K^+ + 2PO_4^{3-} + 3H_2$ [2 marks]

Observation: grey solid dissolves in c'less solution producing c'less, o'less gas.   [1 mark]

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13. Pure water undergoes self-ionisation according to the equation

$$2H_2O\,(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

The equilibrium constant for the reaction is
1.0×10^{-14} at 25°C
5.5×10^{-15} at 10°C

Which of the following statements is correct?

a) At 10°C the pH of water is less than 7, but the water is still neutral.
b) At 10°C the pH of water is less than 7, therefore the water is acidic.
c) At 10°C the pH of water is greater than 7, but the water is still neutral.
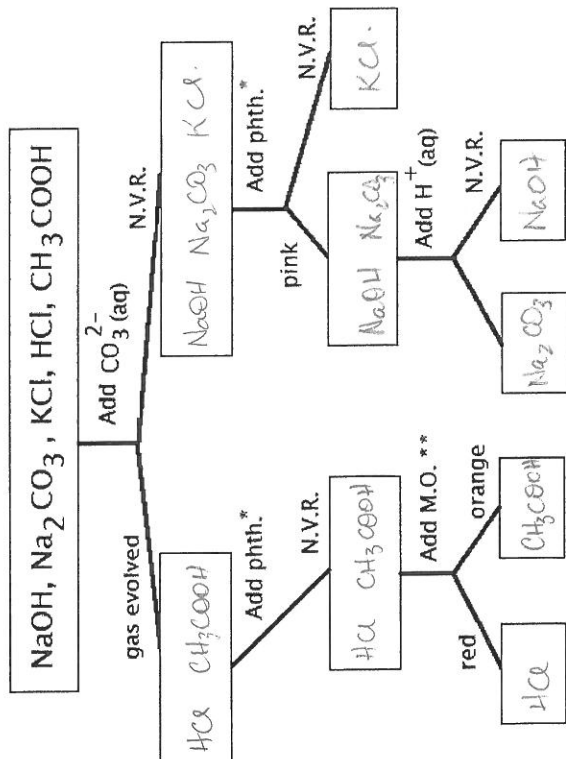d) At 10°C the pH of water is greater than 7, therefore the water is basic.

14. Animals and plants are protected against sharp changes in pH caused by the addition of either acids or bases to their systems by having buffer solution present. A buffer solution is usually composed of:

a) a strong acid and a strong base
b) a salt solution and water.
c) an organic chemical mixture.
d) a weak acid and its conjugate base.

15. If equal volumes of the following pairs of substances were mixed, which mixture would *be the most effective buffer?*

a) 0.1 M Na2SO4 and 0.1 M Na3PO4
b) 0.1 M HNO3 and 0.1 M BaCl2
c) 0.1 M CH3COOH and 0.1 M NaCH3COO.
d) 0.1 M H2CO3(aq) and 0.1 M Na2CO3

2. Five clear, colourless solutions, whose formulas are shown below, are to be identified by carrying out the testing shown in the FLOW CHART below. Write the formulas of the substances that would be recorded in the empty boxes so that finally all 5 would be identified. (NB: N.V.R. means 'no visible reaction'.)

NaOH, Na_2CO_3, KCl, HCl, CH_3COOH

Add CO_3^{2-} (aq)

gas evolved → HCl CH_3COOH
- Add phth.*
  - N.V.R. → HCl CH_3COOH
    - Add M.O. **
      - red → HCl
      - orange → CH_3COOH

N.V.R. → NaOH Na_2CO_3 KCl
- Add phth.*
  - pink → NaOH Na_2CO_3
    - Add H^+ (aq)
      - N.V.R. → NaOH
      - → Na_2CO_3
  - N.V.R. → KCl

* phth = phenolphthalein

M.O. ** = methyl orange

[5 marks]

3. When 0.062 moles of barium hydroxide solid is added to 75.0 ml of 1.2 M HCl eventually a colourless, clear solution is formed.

(a) Which ion is in excess, the H^+(aq) or the OH^-(aq) ?

$n[OH^-] = 0.124 \text{ mol}$ ✓

$n[H^+] = 1.2 \times 0.075 = 0.09 \text{ mol}$ ✓

$OH^- + H^+ \rightarrow H_2O \quad (1:1 \text{ ratio})$

$\therefore \times S \text{ ion} = OH^-$

(b) What is the final pH of the mixture, assuming the final volume remains at 75 ml. [4 marks]

$n(\times S \, OH^-) = 0.034 \text{ mol}$

$V_T = 0.075 \text{ L}$

$c(OH^-) = \dfrac{0.034}{0.075} = 4.53 \times 10^{-1} \text{ M}$

$pOH = 0.344$

$pH = 13.7$

[4 marks]

7

4. If 2.65 g of a dilute ammonia solution requires 32.25 ml of 0.126 M HCl solution to just neutralise it, what is the percentage by mass of ammonia in the solution?

$NH_3 + HCl \Longrightarrow NH_4Cl$

$n(HCl) = 0.126 \times 0.03225 = 4.06 \times 10^{-3} \text{ mol}$

$\therefore n(NH_3) = 4.06 \times 10^{-3} \text{ mol}$

$\therefore m(NH_3) = 4.06 \times 10^{-3} \times 17.034$

$= 6.92 \times 10^{-2} \text{ g}$

$\% \, NH_3 = \dfrac{6.92 \times 10^{-2} \text{ g}}{2.65 \text{ g}} \times 100$

$= 2.61 \, \%$

[5 marks]

5. The major buffer system in the human blood stream is the acid-base pair H_2CO_3 — HCO_3^-(aq).

(a) Which one of the pair acts to soak up, or neutralize, a change which would cause a lowering of pH?

HCO_3^- [1 mark]

(b) Support your answer to the above question with an equation showing the species working to bring pH back to the desired pH level.

$HCO_3^- + H^+ \rightarrow H_2CO_3$

[1 mark]

6. In an experiment to test the solubility of carbon dioxide in water, tablets that dissolve to produce CO_2 were added to equal volumes hot water and ice-cold water. After all reaction had finished, the two solutions were tested with an indicator and dilute sodium hydroxide solution. It was indeed found that more CO_2 had dissolved into the cold water.

Write an equation to show the solution of CO_2 (g) into water and indicate whether the ΔH value for this reaction is positive or negative. [2 marks]

$CO_2 + H_2O \rightleftharpoons H^+ + HCO_3^-$

fwd rxn favoured at $\downarrow$ temp
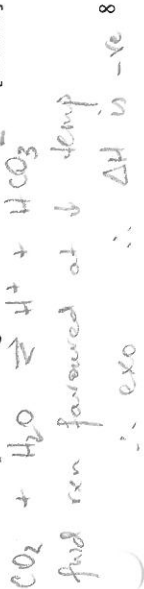
$\therefore$ exo $\quad \therefore \Delta H$ is -ve 8

7. 15.7 mL of a 0.255 mol/L solution of barium chloride is added to 25.0 mL of 0.415 mol/L silver nitrate solution.

(a) Calculate the number of moles of all four ions present in the two solutions BEFORE mixing. [3]

$n(Ba^{2+}) = 0.255 \times 0.0157 = 4 \times 10^{-3}$ mol

$n(Cl^-) = 2 \times 0.255 \times 0.0157 = 8.01 \times 10^{-3}$ mol

$n(Ag^+) = 0.415 \times 0.025 = 1.04 \times 10^{-2}$ mol

$n(NO_3) = 1.04 \times 10^{-2}$ mol

(b) Write the IONIC equation for the reaction that occurs. [1]

$Ag^+ + Cl^- \rightarrow AgCl_{(s)}$

(c) Determine which ion is the limiting reagent. [2]

Rxn $Ag^+ : Cl^-$ is 1:1

$n(Ag^+) > n(Cl^-)$

∴ Cl^- is limiting

(d) Calculate the mass of precipitate produced. [3]

$n(AgCl) = n(Cl^-) = 8.01 \times 10^{-3}$ mol

$m(AgCl) = n \cdot M = 8.01 \times 10^{-3} \times 143.35$

$= 1.15$ g.

End of Test.