Year 12 Chemistry **Topic Test #4 (Acids & Bases) - 2012**

Name: _____ Mark = _____ / 50

Part 1: Multiple Choice Section **10 marks**

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1. **B** 2. **B** 3. **A** 4. **B** 5. **C** 6. **C** 7. **B** 8. **C** 9. **A** 10. **B**

Part 2: Short Answer Section **30 marks**

Question 11 **(6 marks)**

Write balanced ionic equations for the following reactions and describe what you would observe.

(a) Propanoic acid is reacted with sodium carbonate

Equation **$2\ CH_3CH_2COOH(aq) + Na_2CO_3(s) \rightarrow 2\ Na^+(aq) + 2\ CH_3CH_2COO^-(aq) + H_2O(l) + CO_2(g)$** ✓✓

Observation **A white solid dissolves forming a c/less solution and an o/less, c/less gas evolves** ✓

(3 marks)

(b) Solid manganese (IV) oxide is added to sulphuric acid.

Equation **$MnO_2(s) + 4\ H^+(aq) \rightarrow Mn^{4+}(aq) + 2\ H_2O(l)$** ✓✓

Observation **A black solid dissolves forming a c/less solution** ✓

(3 marks)

Question 12 **(4 marks)**

Anions such as hydrogencarbonate (HCO_3^-) and hydrogenphosphate (HPO_4^{2-}) act as bases in aqueous solutions. However, in water, hydrogensulfate ion (HSO_4^-) does not act as a base.

Use equations to explain these observations.

$HCO_3^-(aq) + H_2O(l) \rightarrow H_2CO_3(aq) + OH^-(aq)$

$HPO_4^{2-}(aq) + H_2O(l) \rightarrow H_2PO_4^-(aq) + OH^-(aq)$

increase $[OH^-]$, $\therefore$ basic

$HSO_4^-(aq) + H_2O(l) \rightarrow SO_4^{2-}(aq) + H_3O^+(aq)$ **increase $[H_3O^+]$, $\therefore$ acidic**

Question 13 **(6 marks)**

Phosphoric acid (H_3PO_4) is a polyprotic weak acid.

(a) List all the anions present (in order of decreasing concentration) in a solution of phosphoric acid (excluding hydroxide). Write equations to show how you determined this.

(3 marks)

$H_2PO_4^- < HPO_4^{2-} < PO_4^{3-}$ ✓

Each ionisation of H_3PO_4 occurs to a more limited extent. ✓

$H_3PO_4(aq) + H_2O(l) \rightleftarrows H_2PO_4^-(aq) + H_3O^+(aq)$

$H_2PO_4^-(aq) + H_2O(l) \rightleftarrows HPO_4^{2-}(aq) + H_3O^+(aq)$

$HPO_4^{2-}(aq) + H_2O(l) \rightleftarrows PO_4^{3-}(aq) + H_3O^+(aq)$ ✓

(b) Phosphoric acid is a weak acid. However, the pH of the acid is observed to decreases when heated. Suggest an explanation for this observation.

(3 marks)

If pH decreases, $[H^+]$ increases - this suggests that as the temperature increases, the equilibria above shift to the right. ✓

LCP predicts that an increase temperature causes a shift in endothermic direction. ✓

This means that, as written, they must be endothermic. ✓

Question 14 **(8 marks)**

A swimming pool holds 250 cubic metres of water. The owner tests the water and finds its hydroxide ion concentration, $[OH^-]$, is 5.55×10^{-5} mol L^{-1} at 25°C. (1 cubic metre = 1000 L)

(a) What is the pH of the pool water? (2 marks)

$[H^+] = K_W/[OH^-] = 1 \times 10^{-14} / 5.55 \times 10^{-5} = 1.802 \times 10^{-10}$ mol L^{-1} ✓

$pH = -\log[H^+] = -\log(1.802 \times 10^{-10}) = \underline{9.74}$ ✓

or

$pOH = -\log[OH^-] = -\log(5.55 \times 10^{-5}) = 4.26$
$pH = 14 - pOH = \underline{9.74}$

(b) Thinking the pH is too low, the owner adds to the water 3.00 kg of caustic soda (NaOH). The water pump ensures that the caustic soda dissolves and becomes evenly mixed in the pool. What is the new pH of the water? (6 marks)

$n(NaOH)_{added} = m/M = 3000 / 39.998 = 75.00$ mol ✓

$[NaOH]_{added} = n/V = 75.00 / 250{,}000 = 3.00 \times 10^{-4}$ mol L^{-1} ✓

$[NaOH]_{total} = [NaOH]_{initial} + [NaOH]_{added} = 5.55 \times 10^{-5} + 3.00 \times 10^{-4}$ ✓
$= 3.555 \times 10^{-4}$ mol L^{-1} ✓

$[H^+] = K_W/[OH^-] = 1 \times 10^{-14} / 3.555 \times 10^{-4} = 2.813 \times 10^{-11}$ mol L^{-1} ✓

$pH = -\log[H^+] = -\log(2.813 \times 10^{-11}) = \underline{10.6}$ ✓

or

$pOH = -\log[OH^-] = -\log(3.555 \times 10^{-4}) = 3.45$
$pH = 14 - pOH = \underline{10.6}$

Question 15 **(6 marks)**

(a) You are provided with 100 mL of a 1.0 mol L^{-1} ammonia solution and some solid ammonium chloride Describe how you would use these two substances to prepare a buffer solution with the maximum possible buffer capacity. (2 marks)

Add sufficient mass of ammonium chloride (5.35 g) to ensure an equimolar concentration of ammonia and ammonium.

(b) A 1.0 mol L^{-1} sodium hydroxide solution is added dropwise to your buffer solution. Use equation(s) to describe how the buffer resists a change in pH. (4 marks)

As OH^- is added, it is consumed by reaction with NH_4^+ ✓

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

This means that the $[H^+]$ and therefore pH remains relatively constant ✓

Part 3: Extended Response Section **10 marks**

Question 16

A large quantity of sulphuric acid used as the electrolyte in car batteries was mistakenly contaminated with hydrochloric acid. In order to determine whether the electrolyte was still functional, an analytical chemist is assigned the task of measuring the concentration of both acids in the electrolyte.

The mixture was analysed as follows:

I He used a pipette to remove 20.00 mL of the acid from one of the batteries and dilute this to 250 mL in a volumetric flask. He then placed the diluted battery acid in a burette and titrated it with 20.00 mL samples of 0.2905 mol L^{-1} NaOH. On average he used 17.35 mL of diluted electrolyte solution for end point.

II A second 20.00 mL aliquot taken from the volumetric flask was treated with excess barium nitrate solution and resulted in the precipitation of 0.712 g of barium sulphate.

Determine the concentration of both acids in the battery?

$n(OH^-) = n(NaOH) = c.V = 0.2905 \times 0.0200 = 5.81 \times 10^{-3}$ mol ✓

$n(H^+)_{17.35mL\ dilute} = n(OH^-) = 5.81 \times 10^{-3}$ mol ✓

$n(H^+)_{250mL\ dilute} = n(H^+)_{17.35mL\ dilute} \times 250/17.35 = 0.08372$ mol

$n(H^+)_{20mL\ conc.} = n(H^+)_{250mL\ dilute} = 0.08372$ mol ✓

$n(SO_4^{2-})_{20mL\ dilute} = n(BaSO_4) = m/M = 0.712 / 233.36 = 3.051 \times 10^{-3}$ mol ✓

$n(SO_4^{2-})_{250mL\ dilute} = n(SO_4^{2-})_{20mL} \times 250/20 = 0.03814$ mol

$n(SO_4^{2-})_{20mL\ conc.} = n(SO_4^{2-})_{250mL\ dilute} = 0.03814$ mol ✓

$\therefore \quad n(H_2SO_4) = n(SO_4^{2-}) = 0.03814$ mol ✓

$[H_2SO_4] = n/V = 0.03814 / 0.0200 = \underline{1.961\ mol\ L^{-1}}$ ✓

$n(H^+)_{H2SO4} = 2 \times n(H_2SO_4) = 0.07628$ mol ✓

$n(HC\ell) = n(H^+)_{HC\ell} = n(H^+)_{20mL\ conc.} - n(H^+)_{H2SO4} = 0.007440$ mol ✓

$\therefore \quad [HC\ell] = n/V = 0.0077440 / 0.0200 = \underline{0.372\ mol\ L^{-1}}$ ✓

End of Test