E, C, C, A, E, C

45

PART 2: **SHORT ANSWER** **[29 marks]**

7. Write **equations** for any reactions that occur in the following procedures. If no reaction occurs write 'no reaction'.

[9 marks]

In each case describe IN FULL what you would **observe**, including any

* colours
* odours
* precipitates (give the colour)
* gases evolved (give the colour or describe as colourless)

If a reaction occurs but the change is not visible, you should state this.

a) Solid sodium hydroxide is added a solution of nitric acid.

$NaOH + H^+ \longrightarrow Na^+ + H_2O$ =

White solid dissolves → c.c.s –

b) A piece of zinc is added to a concentrated hydrochloric acid solutin

$Zn + 2H^+ \longrightarrow Zn^{2+} + H_2$ =

Silver solid dissolves → o.c.g –

c) 2.0 $molL^{-1}$ ethanoic acid is added to a piece of solid copper (II) carbonate.

$CuCO_3 + 2CH_3COOH \longrightarrow Cu^{2+} + 2CH_3COO^- + CO_2 + H_2O$ =

blue solid dissolves → o.c.g –

solution blue

8. Give one factor on which the buffering capacity of a buffer solution depends.

[1 marks]

relative amount acid / conjugate base or base / conjugate acid ✓

Actual Amount.

9. Identify by name or formula an example of each of the following:

[3 marks]

a) A weak **inorganic** acid.

H_3PO_4
H_2CO_3 etc...

b) A substance that can be used as a **primary** standard in a titration against a base.

Oxalic acid

c) An oxide that **reacts** with water to produce a basic solution.

Any metal oxide

10. 15.00 mL of 0.100 mol L^{-1} hydrochloric acid is added to 20.00 mL of 0.100 mol L^{-1} sodium hydroxide. Calculate the pH of the resulting solution. [4 marks]

$n(H^+) = 15 \times 10^{-3} \times 0.1 = 0.0015$ mol ✓

$n(OH^-) = 20 \times 10^{-3} \times 0.1 = 0.002$ mol ✓

$H^+ + OH^- \rightarrow H_2O$

$n(OH^-)_{xs} = 0.002 - 0.0015$

$= 5.0 \times 10^{-4}$ mol in 35 mL

$[OH^-] = 0.0143$ mol L^{-1} ✓

K_w: $[H^+] = \frac{1 \times 10^{-14}}{0.0143} = 6.99 \times 10^{-13}$

$pH = -\log_{10}(6.99 \times 10^{-13}) = 12.2$ ✓

11. Distilled water, which has been exposed to air, has a pH of about 5. When it is boiled and then cooled, the pH changes to about 7. The pH of the distilled water prepared in this way then slowly falls back to about 5. Explain with the aid of equations the role of carbon dioxide in these observations.

[3 marks]

CO_2 from the atmosphere dissolves in the water

$CO_2 + H_2O \rightleftharpoons H_2CO_3$ (pH ↓)

As the CO_2 is expelled from H_2O on boiling pH ↑

12. Explain with the aid of chemical equations the following:

a. A solution of sodium hydrogen carbonate is weakly acidic.

$HCO_3^- + H_2O \rightleftharpoons CO_3^{2-} + H_3O^+$ ✓

HCO_3^- donates H^+ to water ✓

b. The hydrogenphosphate ion (HPO_4^{2-}) is a weaker acid than the dihydrogen phospahte ion ($H_2PO_4^{1-}$).

$H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+$ ✓

$HPO_4^{2-} \rightleftharpoons PO_4^{3-} + H^+$

Succesive ionisations of polyprotic acids result in weaker acids ✓

c. The pH of 0.100 $molL^{-1}$ HCl is lower than the pH of 0.100 $molL^{-1}$ carbonic acid.

In 0.1 $molL^{-1}$ HCl, $[H^+] = 0.1$ ✓

H_2CO_3 is a weak acid so

$[H^+] << 0.1\ molL^{-1}$ ✓

∴ pH HCl is lower ✓

d. A 0.1 mol L_1 solution of acetic acid has a pH of 2.93. This changes to a pH of 4.74 when 0.1 mol of sodium acetate is added.

$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$ ✓

Add extra CH_3COO^-, Reverse reaction is favoured to absorb extra CH_3COO^-, ✓

$\downarrow [H_3O^+]$, hence pH ↑. ✓

[9 marks]

PART 3: CALCULATION [10 Marks]

13. Spirits of salts is used in the building industry to clean excess mortar from new brickwork. The active ingredient is hydrochloric acid with a concentration of around 13 mol L^{-1}. In order to precisely determine the concentration of hydrochloric acid in some spirits of salts, a chemist takes a 20.00 mL aliquot and makes this up to 500.0 mL in a volumetric flask. The diluted spirits of salts is analysed by taking 20.00 mL samples of the diluted solution and titrating this with 0.4590 mol L^{-1} sodium hydroxide solution. An average titre of 21.25 mL of base was obtained for the end point. Use this information to determine the following:

a) The moles of sodium hydroxide used in the titration. [2 marks]

$n = c.V$

$= 21.25 \times 10^{-3} \times 0.4590$ ✓

$= 9.75 \times 10^{-3}$ ✓

b) The concentration of hydrochloric acid in the diluted solution. [3 marks]

$n(H^+) = n(OH^-)$ ✓

$= 9.75 \times 10^{-3}$ in 20.0 mL

$[H^+] = \frac{9.75 \times 10^{-3}}{20 \times 10^{-3}}$ ✓

$= \underline{0.4875 \text{ mol L}^{-1}}$ ✓

c) The concentration of the hydrochloric acid in the original spirits of salts. [2 marks]

$\therefore C_1V_1 = C_2V_2$ ✓

$0.485 \times 20 = C_2 500$

$\underline{C_2 = 12.18 \text{ mol L}^{-1}}$ ✓

d) The percentage of hydrochloric acid by mass in the original undiluted spirits of salts. Assume the original solution has a density of 1.18 g mL^{-1}. [3 marks]

$n(HCl) = C.V$

$= 12.18 \times 20 \times 10^{-3}$ ✓

$= 0.2437$ mol

$m(HCl) = 0.2437 \times 36.46$

$= 8.88$ ✓

"m(HCl) spirits" $= 20 \times 1.18$

$= 23.6$ g

$\% = \frac{8.88}{23.6} \times \frac{100}{1}$

$= \underline{37.6\%}$ ✓