Year 12 Chemistry Assignment - Solutions

Due with Validation on Monday 3rd April

(71 marks)

Topic E: Acids and Bases

Name ___________________________

Multiple Choice (1 mark each)

1. The usual purpose of a titration is to

(A) create a primary standard
(B) determine the volume needed for reactants to react with each other
(C) create a secondary standard
☎☜ find the concentration of a solute in a solution ✓

2. An acid-base titration is performed by

(A) adding one solution from a pipette to a carefully measured volume which is placed in a conical flask.
(B) adding one solution from a pipette to a carefully measured volume which is placed in a volumetric flask.
☎ adding one solution from a burette to a carefully measured volume which is placed in a conical flask. ✓
(D) adding one solution from a burette to a carefully measured volume which is placed in a volumetric flask.

3. In pure water the concentration of $H^+(aq)$ and $OH^-(aq)$ ions is equal to

☎ 1×10^{-7} M ✓
(B) 1×10^{-14} M
(C) 1×10^{-7} mol^{-1}
(D) 1×10^{-14} mol^{-1}

4. The Bronsted-Lowry definition for acids and bases defines a base as

☎ a substance which accepts a proton ✓
(B) a substance that donates a proton
(C) a substance that produces H^+ in solution
(D) a substance that produces OH^- in solution

5. The ethanoate ion CH_3COO^- causes a solution to have a pH

(A) equal to 7
(B) less than 7
☎ greater than 7 ✓
(D) that may be neutral or greater than 7 depending on the concentration of the ion.

6. An acid plus a metal produces

(A) salt + carbon dioxide gas
(B) salt + sulphur dioxide gas
(C) salt + water
☎☜ salt + hydrogen gas ✓

7. An acid plus a metal sulfite produces

☎ salt + water + sulphur dioxide gas ✓
(B) salt + hydrogen sulphide gas
(C) salt + water + sulphur trioxide gas
(D) salt + hydrogen gas + sulphur

8. OH^- plus an amphoteric metal hydroxide produces

(A) complex ion + water
(B) complex ion + water + hydrogen gas
(C) complex ion + hydrogen gas
☎☜ complex ion ✓

9. OH^- plus an amphoteric metal plus water produces

(A) complex ion + water
(B) complex ion + water + hydrogen gas
☎ complex ion + hydrogen gas ✓
(D) complex ion

10. The following are amphoteric metals

(A) Al, Mg, Zn
(B) Al, Na, Fe
(C) Al, Cr, Zn ✓
(D) Al, Ca, Zn

11. Which one of the following compounds, when dissolved in water, would form a solution with a pH greater than 7?

(A) NH_4Cl
(B) $Ba(NO_3)_2$
(C) $NaCH_3COO$ ✓
(D) H_3PO_4

12. Which, if any, of the following equations represents a reaction in which water acts as an acid?

(A) $CH_3COOH(aq) + H_2O(l) \text{----->} CH_3COO^-(aq) + H_3O^+(aq)$
(B) $Zn^{2+}(aq) + 4H_2O(l) \text{----->} Zn(H_2O)_4^{2+}(aq)$
(C) $NH_3(aq) + H_2O(l) \text{----->} NH_4^+(aq) + OH^-(aq)$ ✓
(D) $NaOH(s) \text{----->} Na^+(aq) + OH^-(aq)$

13. In deciding which of two acids is stronger, one must know:

(A) the concentration of each acid solution
(B) the pH of each acid solution.
(C) the K_a of each acid ✓
(D) all of the above

14. The conjugate acid of the HPO_4^{2-} ion is

(A) H_3PO_4
(B) $H_2PO_4^-$ ✓
(C) HPO_4^{2-}
(D) PO_4^{3-}

15. Is the ion HPO_4^{2-} an amphoteric substance?

(A) yes ✓
(B) no
(C) sometimes
(D) unable to determine from the given information

16. 100 mL of a 0.010 M solution of barium hydroxide ($Ba(OH)_2$) is diluted by adding 900 mL of water at 25°C. The pH of the resulting solution will be

(A) 2.00
(B) 2.70
(C) 11.00
(D) 11.30 ✓

10 times dilution. Therefore c($Ba(OH)_2$) = 0.0010 M
c(OH-) = 0.0020 M
pOH = -log(0.0020) = 2.70
pH = 14-2.70 = 11.30

17. In which one of the following pairs is the second substance the stronger acid than the first?

(A) HCl CH_3COOH
(B) $H_2PO_4^-$ H_3PO_4 ✓
(C) H_2SO_4 H_2CO_3
(D) H_2O OH^-

18. When the pH of a solution changes from 9 to 12 the

(A) hydroxide ion concentration increases by a factor of 3
(B) hydrogen ion concentration increases by a factor of 3
(C) hydroxide ion concentration decreases by a factor of 1000
(D) hydrogen ion concentration decreases by a factor of 1000 ✓

[H+] reduces from 10^{-9}M to 10^{-12}M
$10^{-9}/10^{-12} = 1000$

19. 10 mL of 0.1 M HCl is added to 1.0 L of water. The pH of the resulting solution is most nearly

(A) 1
(B) 2
(C) 3 ✓
(D) 4

n(H+) = cV = 0.1 x 0.010 = 0.0010
V = 1.01 L
[H+] = n/V = 0.0010/1.01 = 9.9 x 10^{-4}
pH = -log[9.9 x 10^{-4}] = 3

20. 18.0 g of magnesium is added to 200 mL of 2.00 M HCl. The mass, in grams, of magnesium that is left behind after the reaction is closest to

(A) 4.2
(B) 8.4
(C) 13.2 ✓
(D) 15.6

n(Mg) = m/M = 18.0/24.3 = 0.741
n(HCl) = cV = 2.00 x 0.200 = 0.400
Mg + 2HCl => $MgCl_2$ + H_2O
n(Mg)reacting = n(HCl)/2 = 0.400/2 = 0.200
n(Mg)remaining = 0.741-0.200 = 0.541
m(Mg)left = n x M = 0.541 x 24.3 = 13.15

Short Answers and Calculations (51 marks)

21. Write an ionic equation for the reaction between sodium metal and sulfuric acid

[2 marks]

$$2Na(s) + 2H^+_{(aq)} \Rightarrow H_2(g) + 2Na^+(aq)$$

22. Calculate the pH of a 0.0342M solution of barium hydroxide

[3 marks]

c($Ba(OH)_{2(aq)}$) = 0.0342 M
c(OH^-) = 2 x 0.0362 M = 0.0684 M
pOH = -log(0.0684) = 1.165
pH = 14-1.165 = **12.8**

23. Write equations for the successive ionisations of phosphoric acid.

[3 marks]

$$H_3PO_4(aq) \longrightarrow H_2PO_4^-(aq) + H^+(aq)$$

$$H_2PO_4^-(aq) \longrightarrow HPO_4^{2-}(aq) + H^+(aq)$$

$$HPO_4^{2-}(aq) \longrightarrow PO_4^{3-}(aq) + H^+(aq)$$

24. A student performed a neutralisation reaction outlined as followed: She took care to ensure complete neutralisation had occurred, with neither acid nor base in excess. She then used an indicator to measure the pH of the final reaction mixture. When she did this procedure with hydrochloric acid that was neutralised with sodium carbonate solution the final pH was approximately 4. She thought the pH would have been 7. Account for the observed pH value she found.

[3 marks]

The neutralisation reaction is as follows:

$$2HCl_{(aq)} + Na_2CO_{3(aq)} \longrightarrow 2NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

The CO_2(g) reacts with water to form carbonic acid which makes the system slightly acidic and so a pH less than 4 is observed.

25. Identify each of the following as a Strong Electrolyte (**SE**), a Weak Electrolyte (**WE**) or a non-electrolyte (**NE**):

[6 marks]

(a) HCl SE

(b) CH_3COOH WE

(c) NaCl SE

(d) NaOH SE

(e) H_2O NE

(f) $C_6H_{12}O_6$ NE

26.

The following table shows the colours and pH ranges for various indicators.

Indicator	*Colour (low pH)*	*Colour (high pH)*	*pH range for colour change*
Methyl orange	Red	Yellow	3·1–4·4
Bromophenol blue	Yellow	Blue	3·0–4·6
Bromocresol green	Yellow	Blue	3·8–5·4
Methyl red	Pink	Yellow	4·4–6·2
Bromothymol blue	Yellow	Blue	6·0–7·6
Phenol red	Yellow	Red	6·8–8·4
Thymol blue	Yellow	Blue	8·0–9·6
Phenolphthalein	Colourless	Magenta	8·3–10·0

(a) 0·10 mol L^{-1} potassium nitrite (KNO_2) was tested with bromothymol blue and a blue colour was seen. On the basis of this result, write an ionic equation for the reaction between potassium nitrite and water.

[1 mark]

$$NO_2^-(aq) + H_2O(l) \longrightarrow HNO_2(aq) + OH^-(aq)$$

(b) At 25°C, a solution tested with bromothymol blue gives a blue colour, and with thymol blue gives a yellow colour.

(i) Estimate the pH of the solution. 7.6-8.0

(ii) Using your estimate, calculate the hydroxide ion concentration of the solution.

[3 marks]

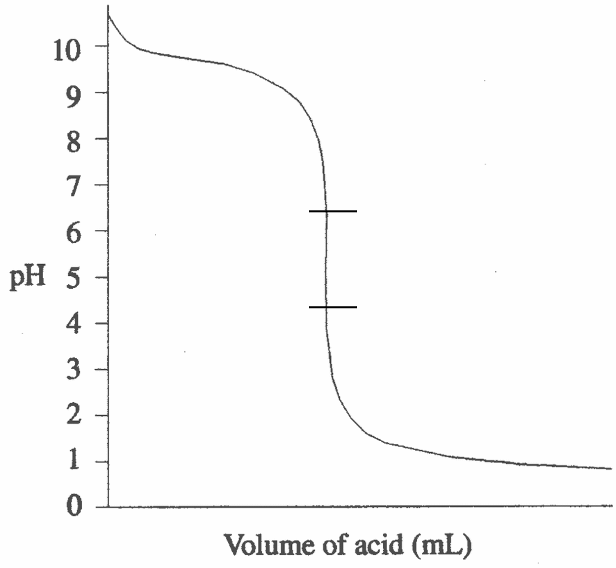
Take a value between 7.6 and 8.0, say 7.8

pOH = 14-7.8 = 6.2
[OH-] = $10^{-6.2}$ = 6.3 x 10^{-7} M

PLEASE TURN OVER

(c) Aqueous ammonia is titrated with hydrochloric acid. The titration curve obtained by using a pH meter is shown below. If a pH meter was not available, what would be a suitable indicator for this titration? Explain your choice.

[3 marks]



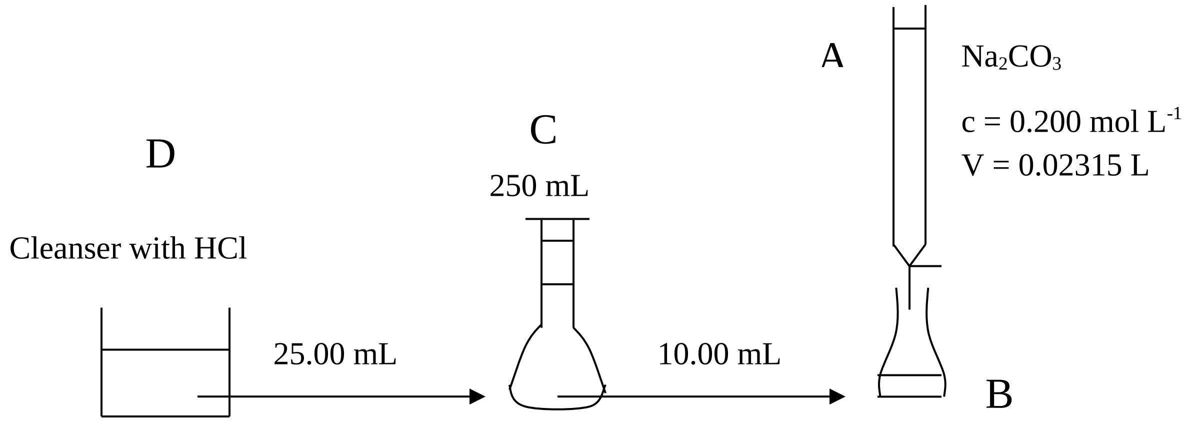
Any indicator where a pH change is between the lines indicated. Lines are points of dramatic pH change. Hence, methyl red would do (others also).

27.

The concentration of hydrochloric acid in a liquid concrete cleaner was determined using the following method.

A 25.00 mL sample was diluted to 250 mL in a volumetric flask. A pipette was used to transfer a 10.00 mL sample of this diluted concrete cleaner to a conical flask. An indicator was added and the sample of diluted concrete cleaner was titrated against a 0.200 M solution of sodium carbonate in a burette. The titre was found to be 23.15 mL.

(a) Calculate the concentration of HCl in the original sample of concrete cleaner.



$2HCl(aq) + Na_2CO_3(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$

$n(Na_2CO_3)_A = cV = 0.200 \times 0.02315 = 0.00463$
$n(HCl)_B = 2 \times n(Na_2CO_3)_A = 2 \times 0.00463 = 0.00926$ mol
$c(HCl)_C = (n(HCl)_B)/0.0100 = 0.00926/0.01 = 0.926$ M
$n(HCl)_C = cV = 0.926 \times 0.250 = 0.2315$ mol
$c(HCl)_D = n/V = 0.2315/0.025 =$ **9.26 M**

(b) When preparing for the above analysis, it is necessary to carefully wash and rinse all items of volumetric glassware before use.

Show which liquid should be used for the **final** rinse for each of the three items in the table below by placing a tick in the appropriate box.

[3 marks]

	distilled water	dilute concrete cleaner solution	standard sodium carbonate solution
pipette		✓	
burette			✓
conical flask	✓		

28.

The contents of a laboratory reagent bottle containing solid potassium hydroxide, $KOH_{(s)}$, has been contaminated by moisture. You have been given the job of determining the extent of contamination. This is to be done by titrating a solution of this KOH with a standardised hydrochloric acid solution (HCl) of pH 1.14. You are to use the following procedure:

Step 1: Dissolve 2.80 g of the contaminated $KOH_{(s)}$ into 500.0 mL of solution.

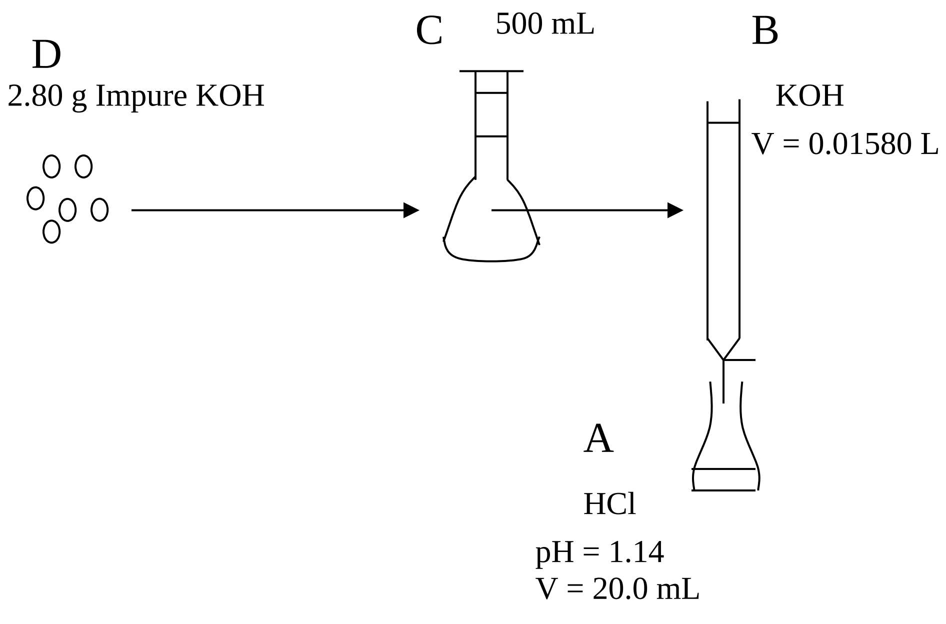
Step 2: Fill a burette with this solution and use it to titrate a 20.00 mL sample of the $HCl_{(aq)}$ using a suitable indicator.

Step 3: Repeat the titrations until a consistent end point is obtained.

After completing the titrations, the following data is available:

- Titration end point = 15.80 mL of $KOH_{(aq)}$.
- pH of $HCl_{(aq)}$ = 1.14.

Calculate the percentage by mass of moisture in the contaminated KOH(s)



$n(HCl)_A = cV = 10^{-1.14} \times 0.020 = 1.45 \times 10^{-3}$ mol
$n(KOH)_B = n(HCl)_A = 1.45 \times 10^{-3}$ mol
$c(KOH)_B = n/V = (1.45 \times 10^{-3})/0.01580 = 9.17 \times 10^{-2}$ M
$c(KOH)_C = 9.17 \times 10^{-2}$ M
$n(KOH)_C = c \times V = (9.17 \times 10^{-2}) \times 0.500 = 0.0459$
$m(NaOH)_D = n \times M = 0.0459 \times 56.1056 = 2.58$ g
%(KOH) in impure sample = (2.58/2.80) x 100 = **92.0%**

29.

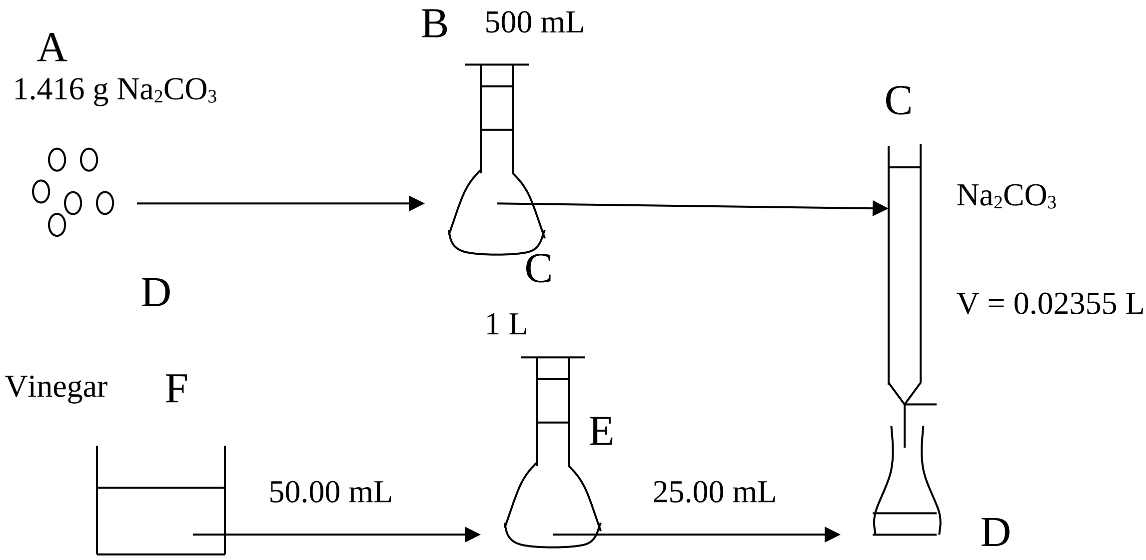
A supermarket brand of vinegar is to be analysed for its ethanoic acid content by a titration technique. This requires the preparation of a $Na_2CO_3(aq)$ primary standard. The primary standard is made by dissolving 1.416 g of anhydrous $Na_2CO_3(s)$ in some distilled water and making the solution up to exactly 500.0 mL using a volumetric flask.

A 50.00 mL sample of the vinegar is diluted to exactly 1.000 L in another volumetric flask. Four 25.00 mL samples of this solution are placed into separate conical flasks and titrated with the $Na_2CO_3(aq)$ primary standard. On average 23.55 mL of the Na_2CO_3 solution was required for equivalence.

$Na_2CO_3(aq) + 2CH_3COOH(aq)$ -------> $2NaCH_3COO(aq) + H_2O(l) + CO_2(g)$

Determine the percentage by mass of ethanoic acid in the undiluted vinegar if this vinegar has a density of 1.060 g mL^{-1}.

[10 marks]



$n(Na_2CO_3)_A = m/M = 1.416/105.9884 = 1.336 \times 10^{-2}$ mol
$c(Na_2CO_3)_B = n/V = (1.336 \times 10^{-2})/0.500 = 2.67 \times 10^{-2}$ M
$n(Na_2CO_3)_{\text{added from Burette C}} = cV = (2.67 \times 10^{-2}) \times 0.02355 = 6.29 \times 10^{-4}$ mol
$n(CH_3COOH)_D = 2 \times n(Na_2CO_3)_{\text{added from Burette C}} = 2 \times (6.29 \times 10^{-4}) = 1.26 \times 10^{-3}$ mol
$c(CH_3COOH)_E = n/V = (1.26 \times 10^{-3})/0.02500 = 5.03 \times 10^{-2}$ M
$n(CH_3COOH)_E = cV = (5.03 \times 10^{-2}) \times 1 = 5.03 \times 10^{-2}$ mol
$c(CH_3COOH)_E = n/V = (5.03 \times 10^{-2})/0.0500 = 1.01$ M

density of vinegar = 1060 g / L
therefore, mass of 1 L solution = 1060 g
number of moles CH_3COOH in 1 L = 1.01
therefore, mass of CH_3COOH in 1 L = n x M = 1.01 x 60.0519 = 60.5g
$\%(CH_3COOH)$ = [(mass of CH3COOH)/(mass of solution)] x 100
= (60.5/1060) x 100 = **5.7%**