education

Department of Education
FREE STATE PROVINCE

PHYSICAL SCIENCES TRAINING MANUAL
CAPS

ACIDS AND BASES
ANSWERS TO QUESTIONS
GRADE 12

This document consists 9 of pages

Daily task 1: Homework/Classwork

Question 1: Multiple choice questions

1.1	C	1.2	C	1.3	A	1.4	D
1.5	C	1.6	D	1.7	C	1.8	A
1.9	C	1.10	D (largest ionic charge, most difficult to remove H^+.)				
1.11	A	1.12	D				

Contextual questions

Question 2

2.1

2.1.1	NH_4^+	2.1.2	NH_3	2.1.3	$C_{10}H_{15}N_2^+$	2.1.4	H_3O^+

2.2

2.2.1	$Cℓ^-$	2.2.2	HCO_3^-	2.2.3	OH^-	2.2.4	PO_4^{3-}

Question 3

3.1

3.1.1 $HCℓ + H_2O \rightarrow H_3O^+ + Cℓ^-$
a1 b2 a2 b1

3.1.2 $O^{2-} + H_2O \rightarrow OH^- + OH^-$
b1 a2 a1 b2

3.1.3 $NH_4^+ + BrO_3^- \rightarrow NH_3 + HBrO_3$
a1 b2 b1 a2

3.1.4 $NH_3 + H_3PO_4 \rightarrow NH_4^+ + H_2PO_4^-$
b1 a2 a1 b2

3.1.5 $HPO_4^{2-} + HSO_4^- \rightarrow H_2PO_4^- + SO_4^{2-}$
b1 a2 a1 b2

3.2 H_2O; $H_2PO_4^-$; OH^-

Question 4

4.1 $HNO_2(aq) + HCO_3^-(aq) \rightleftharpoons NO_2^-(aq) + H_2CO_3(aq)$

4.2 A pair of compounds or ions that differ by the presence of one H^+ ion.

4.3 HNO_2(aq) and NO_2^-(aq) OR HCO_3^-(aq) and H_2CO_3(aq)

Question 5

5.1 $NH_4^+ + HCO_3^- \rightleftharpoons NH_3 + H_2CO_3$

5.2 HCO_3^- and NH_3

5.3 The reaction will favour the products. HCO_3^- will have, due to its negative charge, a greater tendency to accept a H^+ tan the neutral NH_3, a weaker base.
NH_4^+ is a stronger acid than H_2CO_3 and will donate a H^+ easier than H_2CO_3.

Question 6

6.1 $C\ell^-$; CH_3COO^-; OH^-

6.2 NH_4^+; HSO_4^-; H_3O^+

Daily task 2: Homework/Classwork

Question 1: Multiple choice questions

1.1	B	1.2	D
1.3	C	1.4	B
1.5	A (strongest acid of the four acids)	1.6	A
1.7	B	1.8	C
1.9	C	1.10	B
1.11	C	1.12	B
1.13	C		

Contextual questions

Question 2

2.1 Neutral

Salt of a strong acid and a strong base. Na^+ and NO_3^- will not undergo hydrolysis.

2.2 Basic

Salt of strong base and weak acid.

Na^+ will not undergo hydrolysis.

HCO_3^- is the conjugate base of a weak acid and will undergo hydrolysis:

$HCO_3^- + H_2O \rightleftharpoons H_2CO_3 + OH^-$

Formation of OH^- causes solution to be basic.

2.3 Basic

Salt of strong base and weak acid.

K^+ will not undergo hydrolysis.

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

Formation of OH^- causes solution to be basic.

2.4 Acidic

Salt of strong acid and a weak base.

NO_3^- will not undergo hydrolysis.

NH_4^+ the conjugate acid of a weak base and will undergo hydrolysis:

$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$

Formation of H_3O^+ causes solution to be acidic.

Question 3

3.1 The reaction of a salt with water.

OR

The reaction of an ion with water to produce the conjugate acid and a hydroxide ion or the conjugate base and a hydronium ion.

3.2 NaOH; HCO_3^-

3.3 NaOH – strong base; HCO_3^- - weak acid.

3.4 Greater than 7

3.5 $CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$

Question 4

4.1 NH_3 and HNO_3

4.2 NH_3 – weak base; HNO_3 – strong acid

4.3 Less than 7

4.4 $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$

Formation of H_3O^+ causes solution to be acidic.

Daily task 3: Homework/Classwork

Question 1: Multiple choice questions

1.1 A
1.2 A
1.3 B
1.4 B
1.5 A
1.6 B

Contextual questions

Question 2

$2NaOH + H_2S \rightleftharpoons Na_2S + 2H_2O$

$n_b = c_bV_b = (0,3)(31,8 \times 10^{-3}) = 9,54 \times 10^{-3}$ mol

From balanced equation: $\frac{n_a}{n_b} = \frac{1}{2} \therefore n_a = \frac{1}{2}n_b \therefore n_a = \frac{1}{2}2(9,54 \times 10^{-3}) = 4,77 \times 10^{-3}$ mol

$c_a = \frac{n}{V} = \frac{4,77 \times 10^{-3}}{25 \times 10^{-3}} = 0,19\ mol \cdot dm^{-3}$

Question 3

$2HNO_3 + Sr(OH)_2 \rightarrow Sr(NO_3)_2 + 2H_2O$

$n_b = c_bV_b = (0,25)(25 \times 10^{-3}) = 6,25 \times 10^{-3}$ mol

From balanced equation: $\frac{n_a}{n_b} = \frac{2}{1} \therefore n_a = 2n_b \therefore n_a = 2(6,25 \times 10^{-3}) = 0,0125$ mol

$c_a = \frac{n}{V} \therefore 0,3 = \frac{0,0125}{V} \therefore V = 0,04167\ dm^3 = 41,67\ cm^3$

Question 4

4.1 A solution of precisely known concentration.

4.2 It ionises completely in water.

4.3 $H_2SO_4(\ell) + 2H_2O(\ell) \rightarrow 2H_3O^+(aq) + SO_4^{2-}(aq)$

4.4 $n_b = c_bV_b = (0,2)(20 \times 10^{-3}) = 4 \times 10^{-3}$ mol

4.5 From balanced equation: $\frac{n_a}{n_b} = \frac{1}{2} \therefore n_a = \frac{1}{2}n_b \therefore n_a = \frac{1}{2}(4 \times 10^{-3}) = 2 \times 10^{-3}$ mol

4.6 $c_a = \frac{n}{V} = \frac{2 \times 10^{-3}}{12 \times 10^{-3}} = 0,17\ mol \cdot dm^{-3}$

4.7 Methyl orange
Weak base with strong acid and pH at equivalence point will be smaller than 7.

Question 5
5.1 A strong acid ionises completely in water.

5.2 $CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$

5.3
5.3.1 pH = -log[H_3O^+] $\therefore$ [H_3O^+] = 10^{-pH} = 10^{-3} = 1 x 10^{-3} mol·dm^{-3}

5.3.2 No

5.3.3 [H_3O^+] < [acid] and thus the acid is only partially ionised and is a weak acid.

5.4 $n_b = c_bV_b$ = (0,5)(28 x 10^{-3}) = 0,014 mol
From balanced equation: $\frac{n_a}{n_b} = \frac{1}{1} \therefore n_a = n_b$ = 0,014 mol
n(acid in excess) = 0,014 mol
n(acid in flask) = c_aV_a = (1,0)(50 x 10^{-3}) = 50 x 10^{-3} mol
n(acid reacted) = 50 x 10^{-3} - 0,014 = 0,036 mol
Mole $CaCO_3$: From balanced equation: $\frac{n_a}{n_b} = \frac{2}{1} \therefore n_b = \frac{1}{2} n_b$ = $\frac{1}{2}$(0,036) = 0,018 mol
Mass $CaCO_3$: $n = \frac{m}{M}$ $\therefore$ 0,018 = $\frac{m}{100}$ $\therefore$ m = 1,8 g

Daily task 4: Homework/Classwork

Question 1: Multiple choice questions

1.1 A
1.2 B
1.3 D
1.4 C
1.5 D

Contextual questions

Question 2
2.1 pH = -log[H_3O^+] = -log(2,9 x 10^{-4}) = 3,54.

2.2 Acidic

Question 3
3.1 pH = -log[H_3O^+] = 7,4
$\therefore$ [H_3O^+] = 10^{-pH} = $10^{-7,4}$ = 3,98 x 10^{-8} mol·dm^{-3}

3.2 pH = -log[H_3O^+] = 3,16
$\therefore$ [H_3O^+] = 10^{-pH} = $10^{-3,16}$ = 6,92 x 10^{-4} mol·dm^{-3}

Question 4

4.1 $K_w = [H_3O^+][OH^-] = 1{,}0 \times 10^{-14}$

$\therefore [H_3O^+](2{,}5) = 1{,}0 \times 10^{-14}$

$\therefore [H_3O^+] = 4 \times 10^{-15}\ mol{\cdot}dm^{-3}$

$pH = -log[H_3O^+] = -log(4 \times 10^{-15}) = 14{,}39$

OR

$[OH^-] = [KOH] = 2{,}5$

$pOH = -log[2{,}5] = -\ 0{,}397$

$pH + pOH = 14 \therefore pH + (-0{,}397) = 14 \therefore pH = 14{,}39$

4.2 $pH = -log[H_3O^+] = 13{,}48$

$\therefore [H_3O^+] = 10^{-pH} = 10^{-13{,}48} = 3{,}31 \times 10^{-14}\ mol{\cdot}dm^{-3}$

4.3 $pH = -log[H_3O^+] = -log(2 \times 1{,}5) = -\ 0{,}48$

4.4 $pH + pOH = 14 \therefore 10{,}6 + pOH = 14 \therefore pOH = 3{,}4$

$pOH = -log[OH^-] \therefore [OH^-] = 10^{-3{,}4} = 3{,}98 \times 10^{-4}\ mol{\cdot}dm^{-3}$

Question 5

5.1 $HC\ell(aq) + NaOH(aq) \rightarrow NaC\ell(aq) + H_2O(\ell)$

5.2 $n_a = c_aV_a = (0{,}5)(1) = 0{,}5\ mol$

5.3 $n_b = n_a = 0{,}5\ mol$

5.4 $HC\ell$

5.5 n_a(in excess) = 0,5 – 0,06 = 0,44 mol

$$c_a = \frac{n}{V} = \frac{0{,}44}{1} = 0{,}44\ mol{\cdot}dm^{-3}$$

$[H_3O^+] = [HC\ell] = 0{,}44\ mol{\cdot}dm^{-3}$

$pH = -log[H_3O^+] = -log(0{,}44) = 0{,}36$

Daily task 5: Homework/Classwork

Question 1: Multiple choice questions

1.1	D	1.2	A
1.3	B	1.4	B
1.5	C		

Daily task 6: Homework/Class work

Question 1: Multiple choice questions

1.1	B	1.2	A
1.3	C	1.4	D
1.5	B	1.6	A
1.7	D	1.8	C
1.9	B	1.10	B
1.11	A	1.12	D

Contextual questions

Question 2

2.1 $NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$

2.2 $n_a = c_aV_a = (0,2)(23,75 \times 10^{-3}) = 4,75 \times 10^{-3}$ mol

From balanced equation: $\frac{n_a}{n_b} = \frac{1}{1} \therefore n_a = n_b \ \therefore\ n_b = 4,75 \times 10^{-3}$ mol

2.3 Mass $NaHCO_3$: $n = \frac{m}{M} \ \therefore\ 4,75 \times 10^{-3} = \frac{m}{84} \ \therefore\ m = 0,399$ g

%Purity = $\frac{0,399}{0,4} \times 100 = 99,75\%$

Question 3

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

$n_a = c_aV_a = (0,33)(37 \times 10^{-3}) = 0,012$ mol

From balanced equation: $\frac{n_a}{n_b} = \frac{1}{2} \therefore n_b = 2n_a \ \therefore\ n_b = 2(0,012) = 0,024$ mol

$n_b = c_bV_b \ \therefore\ 0,024 = 0,53V_b \ \therefore\ V_b = 0,046 \text{ dm}^3 = 46 \text{ cm}^3$l

Question 4

4.1 Battery acid

4.2 $pH = -\log[H_3O^+] = 13,48$

$\therefore\ [H_3O^+] = 10^{-pH} = 10,^{-4,2} = 6,31 \times 10^{-5}$ mol·dm^{-3}

$K_w = [H_3O^+][OH^-] = 1,0 \times 10^{-14}$

$\therefore\ [OH^-](6,31 \times 10^{-5}) = 1,0 \times 10^{-14}$

$\therefore\ [OH^-] = 1,58 \times 10^{-10}$ mol·dm^{-3}

4.3

4.3.1 Increases

4.3.2 Increases

Question 5

5.1 Acid ionises/dissociates (almost) completely in water.

5.2 $n(NaOH) = c_bV_b = (0,5)(28 \times 10^{-3}) = 0,014$ mol

From balanced equation: $\frac{n_a}{n_b} = \frac{1}{1} \therefore n_a = n_b = 0,014$ mol

n(HCℓ originally) = $c_aV_a = (1)(50 \times 10^{-3}) = 0,05$ mol

n(HCℓ reacted with $CaCO_3$) = 0,05 – 0,014 = 0,036 mol

n($CaCO_3$ reacted):

From balanced equation: $\frac{n_a}{n_b} = \frac{2}{1} \therefore n_b = \frac{1}{2}n_a = \frac{1}{2}(0,036) = 0,018$ mol

$n = \frac{m}{M} \ \therefore\ 0,01 = \frac{m}{286} \ \therefore\ m = 2,86$ g

Question 6

6.1

6.1.1 An acid that can donate two H^+ ions.

6.1.2 H_2SO_4; $(COOH)_2$; H_2S

6.2

6.2.1 pH = $-\log[H_3O^+] = -\log(1) = 0{,}1\ mol\cdot dm^{-3}$

6.2.2 Increase

6.3

6.3.1 $Na_2CO_3 + 2HC\ell \rightarrow 2NaC\ell + H_2O + CO_2$

6.3.2 $n_a = c_aV_a = (0{,}1)(200 \times 10^{-3}) = 0{,}02$ mol

From balanced equation: $\frac{n_a}{n_b} = \frac{2}{1} \therefore n_b = \frac{1}{2}n_a = \frac{1}{2}(0{,}02) = 0{,}01$ mol

Mass $CaCO_3$: $n = \frac{m}{M} \therefore 0{,}01 = \frac{m}{286} \therefore m = 2{,}86$ g

6.3.3 Methyl red

6.3.4 Titration of strong acid and weak base. pH at equivalence point is lower than 7/acidic which is in the colour change range of methyl red.

Question 7

When a solution of hydrochloric acid is added the concentration of $H_3O^+(aq)$ ions increases (common ion. The reverse reaction is favoured to reduce the $[H_3O^+(aq)]$.
More $C_{20}H_{14}O_4(aq) + 2H_2O(\ell)$ are formed and the solution turns/ is colourless.

Question 8

8.1 $pH = -\log[H_3O^+] = -\log[3{,}2 \times 10^{-5}] = 4{,}49$
pH < 5,5 and therefore fish species will not survive.

8.2

8.2.1 $n_b = c_bV_b = (1{,}0)(100 \times 10^{-3}) = 100 \times 10^{-3}$ mol

8.2.2 $n_a = c_aV_a = (0{,}3)(45 \times 10^{-3}) = 0{,}0135$ mol

From balanced equation: $\frac{n_a}{n_b} = \frac{1}{2} \therefore n_b = 2n_a = 2(0{,}0135) = 0{,}027$ mol

8.2.3 n(NaOH used with $NH_4C\ell$) = (0,1 – 0,027) = 0,073 mol
But 1 mol NaOH reacts with 1 mol $NH_4C\ell$
$\therefore$ 0,073 mol NaOH reacts with 0,073 mol $NH_4C\ell$
$\therefore$ m ($NH_4C\ell$) = nM = (0,073)(53,5) = 3,91 g

8.2.4 Bromothymol blue

8.2.5 The equivalence point of the titration of a strong acid (H_2SO_4) with a strong base (NaOH) is at pH = 7 which is within the colour change range of bromothymol blue.

Question 9

9.1 $c_b = \frac{m}{MV} = \frac{8}{(40)(350 \times 10^{-3})}$ = 0,57 mol·dm^{-3}

$n_b = c_bV_b$ = (0,57)(15 x 10^{-3}) = 8,57 x 10^{-3} mol

From balanced equation: $\frac{n_a}{n_b} = \frac{1}{2} \therefore n_a = \frac{1}{2}n_b$ = $\frac{1}{2}$(8,57 x 10^{-3}) = 4,29 x 10^{-3} mol

$c_a = \frac{n}{V}$ = $\frac{4,29 \times 10^{-3}}{20 \times 10^{-3}}$ = 0,21 mol·dm^{-3}

9.2

9.2.1 $HC\ell + H_2O \rightarrow H_3O^+ + C\ell^-$

HCℓ is a strong acid and ionises completely in water to form H_3O^+ ions that causes the pH to decrease.

9.2.2 $Na_2CO_3 + 2HC\ell \rightarrow 2NaC\ell + H_2O + CO_2$

pH = -log[H_3O^+] = 4

∴ [H_3O^+] = 10^{-pH} = 10^{-4} = 1 x 10^{-4} mol·dm^{-3}

$n_a = c_aV_a$ = (1 x 10^{-4})(1) = 1 x 10^{-4} mol

From balanced equation: $\frac{n_a}{n_b} = \frac{2}{1} \therefore n_b = \frac{1}{2}n_a$ = $\frac{1}{2}$(1 x 10^{-4}) = 0,5 x 10^{-4} mol

Mass $CaCO_3$: $n = \frac{m}{M}$ ∴ 0,5 x 10^{-4} = $\frac{m}{106}$ ∴ m = 5,3 x 10^{-3} g

9.2.3 Increase salinity o water / Increase the salt concentration in water.