



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

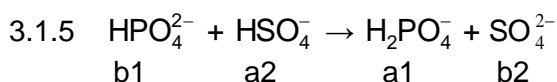
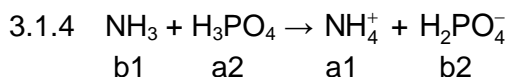
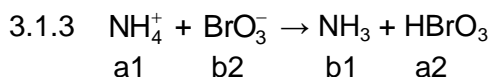
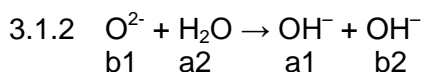
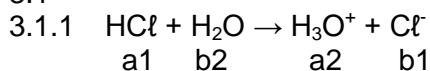
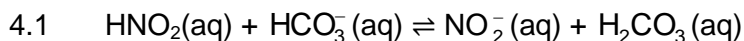
- | | | | | | | | |
|-------|------------------------------|-------|-----------------|-------|---|-------|-------------------------------|
| 2.1.1 | NH ₄ ⁺ | 2.1.2 | NH ₃ | 2.1.3 | C ₁₀ H ₁₅ N ₂ ⁺ | 2.1.4 | H ₃ O ⁺ |
|-------|------------------------------|-------|-----------------|-------|---|-------|-------------------------------|

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

3.2 H₂O; H₂PO₄⁻; OH⁻**Question 4**4.2 A pair of compounds or ions that differ by the presence of one H⁺ ion.4.3 HNO₂(aq) and NO₂⁻(aq) OR HCO₃⁻(aq) and H₂CO₃(aq)**Question 5**5.2 HCO₃⁻ and NH₃5.3 The reaction will favour the products. HCO₃⁻ will have, due to its negative charge, a greater tendency to accept a H⁺ than the neutral NH₃, a weaker base.NH₄⁺ is a stronger acid than H₂CO₃ and will donate a H⁺ easier than H₂CO₃.

Question 66.1 Cl^- ; 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		

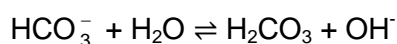
Contextual questions**Question 2**

2.1 Neutral

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

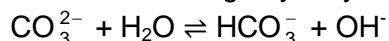
2.2 Basic

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:Formation of OH^- causes solution to be basic.

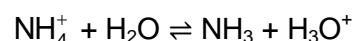
2.3 Basic

Salt of strong base and weak acid.

 K^+ will not undergo hydrolysis.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:Formation of H_3O^+ causes solution to be acidic.**Question 3**

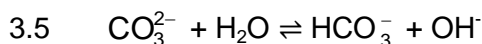
3.1 The reaction of a salt with water.

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



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 $\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{NH}_3 + \text{H}_3\text{O}^+$
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

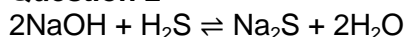
1.4 B

1.5 A

1.6 B

Contextual questions

Question 2

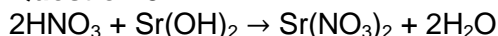


$$n_b = c_b V_b = (0,3)(31,8 \times 10^{-3}) = 9,54 \times 10^{-3} \text{ mol}$$

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

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

Question 3



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

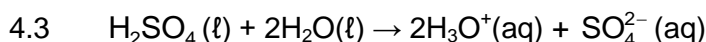
$$\text{From balanced equation: } \frac{n_a}{n_b} = \frac{2}{1} \therefore n_a = 2n_b \therefore n_a = 2(6,25 \times 10^{-3}) = 0,0125 \text{ mol}$$

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

Question 4

4.1 A solution of precisely known concentration.

4.2 It ionises completely in water.



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

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

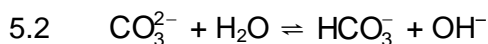
4.6 $c_a = \frac{n}{V} = \frac{2 \times 10^{-3}}{12 \times 10^{-3}} = 0,17 \text{ mol} \cdot \text{dm}^{-3}$

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.



5.3

$$5.3.1 \quad \text{pH} = -\log[\text{H}_3\text{O}^+] \therefore [\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-3} = 1 \times 10^{-3} \text{ mol}\cdot\text{dm}^{-3}$$

5.3.2 No

5.3.3 $[\text{H}_3\text{O}^+] < [\text{acid}]$ and thus the acid is only partially ionised and is a weak acid.

$$5.4 \quad n_b = c_b V_b = (0,5)(28 \times 10^{-3}) = 0,014 \text{ mol}$$

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

$$n(\text{acid in excess}) = 0,014 \text{ mol}$$

$$n(\text{acid in flask}) = c_a V_a = (1,0)(50 \times 10^{-3}) = 50 \times 10^{-3} \text{ mol}$$

$$n(\text{acid reacted}) = 50 \times 10^{-3} - 0,014 = 0,036 \text{ mol}$$

$$\text{Mole CaCO}_3: \text{From balanced equation: } \frac{n_a}{n_b} = \frac{2}{1} \therefore n_b = \frac{1}{2} n_a = \frac{1}{2} (0,036) = 0,018 \text{ mol}$$

$$\text{Mass CaCO}_3: n = \frac{m}{M} \therefore 0,018 = \frac{m}{100} \therefore m = 1,8 \text{ g}$$

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**

$$2.1 \quad \text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(2,9 \times 10^{-4}) = 3,54.$$

2.2 Acidic

Question 3

$$3.1 \quad \text{pH} = -\log[\text{H}_3\text{O}^+] = 7,4 \\ \therefore [\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-7,4} = 3,98 \times 10^{-8} \text{ mol}\cdot\text{dm}^{-3}$$

$$3.2 \quad \text{pH} = -\log[\text{H}_3\text{O}^+] = 3,16 \\ \therefore [\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-3,16} = 6,92 \times 10^{-4} \text{ mol}\cdot\text{dm}^{-3}$$

Question 4

$$4.1 \quad K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1,0 \times 10^{-14}$$

$$\therefore [\text{H}_3\text{O}^+](2,5) = 1,0 \times 10^{-14}$$

$$\therefore [\text{H}_3\text{O}^+] = 4 \times 10^{-15} \text{ mol}\cdot\text{dm}^{-3}$$

$$\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(4 \times 10^{-15}) = 14,39$$

OR

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

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

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

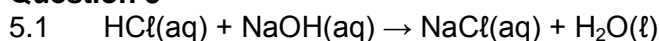
$$4.2 \quad \text{pH} = -\log[\text{H}_3\text{O}^+] = 13,48$$

$$\therefore [\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-13,48} = 3,31 \times 10^{-14} \text{ mol}\cdot\text{dm}^{-3}$$

$$4.3 \quad \text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(2 \times 1,5) = -0,48$$

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

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

Question 5

$$5.2 \quad n_a = c_a V_a = (0,5)(1) = 0,5 \text{ mol}$$

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



$$5.5 \quad n_a(\text{in excess}) = 0,5 - 0,06 = 0,44 \text{ mol}$$

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

$$[\text{H}_3\text{O}^+] = [\text{HCl}] = 0,44 \text{ mol}\cdot\text{dm}^{-3}$$

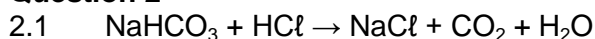
$$\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(0,44) = 0,36$$

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 |

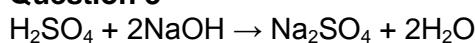
Contextual questions**Question 2**

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

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

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

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

Question 3

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

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

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

Question 4

4.1 Battery acid

4.2 $\text{pH} = -\log[\text{H}_3\text{O}^+] = 13,48$
 $\therefore [\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-13,48} = 6,31 \times 10^{-14} \text{ mol}\cdot\text{dm}^{-3}$

$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1,0 \times 10^{-14}$

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

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

4.3

4.3.1 Increases

4.3.2 Increases

Question 5

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

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

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

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

$n(\text{HCl reacted with CaCO}_3) = 0,05 - 0,014 = 0,036 \text{ mol}$

$n(\text{CaCO}_3 \text{ reacted})$:

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

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

Question 6

6.1

6.1.1 An acid that can donate two H⁺ ions.6.1.2 H₂SO₄; (COOH)₂; H₂S

6.2

6.2.1 $\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(1) = 0,1 \text{ mol}\cdot\text{dm}^{-3}$

6.2.2 Increase

6.3

6.3.1 $\text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$ 6.3.2 $n_a = c_a V_a = (0,1)(200 \times 10^{-3}) = 0,02 \text{ mol}$ From balanced equation: $\frac{n_a}{n_b} = \frac{2}{1} \therefore n_b = \frac{1}{2} n_a = \frac{1}{2} (0,02) = 0,01 \text{ mol}$ Mass CaCO₃: $n = \frac{m}{M} \therefore 0,01 = \frac{m}{286} \therefore m = 2,86 \text{ g}$

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 7When a solution of hydrochloric acid is added the concentration of H₃O⁺(aq) ions increases (common ion). The reverse reaction is favoured to reduce the [H₃O⁺(aq)].More C₂₀H₁₄O₄(aq) + 2H₂O(l) are formed and the solution turns/ is colourless.**Question 8**8.1 $\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log[3,2 \times 10^{-5}] = 4,49$
pH < 5,5 and therefore fish species will not survive.

8.2

8.2.1 $n_b = c_b V_b = (1,0)(100 \times 10^{-3}) = 100 \times 10^{-3} \text{ mol}$ 8.2.2 $n_a = c_a V_a = (0,3)(45 \times 10^{-3}) = 0,0135 \text{ mol}$ From balanced equation: $\frac{n_a}{n_b} = \frac{1}{2} \therefore n_b = 2n_a = 2(0,0135) = 0,027 \text{ mol}$ 8.2.3 $n(\text{NaOH used with NH}_4\text{Cl}) = (0,1 - 0,027) = 0,073 \text{ mol}$ But 1 mol NaOH reacts with 1 mol NH₄Cl $\therefore 0,073 \text{ mol NaOH reacts with } 0,073 \text{ mol NH}_4\text{Cl}$ $\therefore m(\text{NH}_4\text{Cl}) = nM = (0,073)(53,5) = 3,91 \text{ g}$

8.2.4 Bromothymol blue

8.2.5 The equivalence point of the titration of a strong acid (H₂SO₄) with a strong base (NaOH) is at pH = 7 which is within the colour change range of bromothymol blue.

Question 9

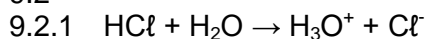
$$9.1 \quad c_b = \frac{m}{MV} = \frac{8}{(40)(350 \times 10^{-3})} = 0,57 \text{ mol}\cdot\text{dm}^{-3}$$

$$n_b = c_b V_b = (0,57)(15 \times 10^{-3}) = 8,57 \times 10^{-3} \text{ mol}$$

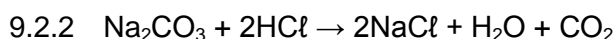
$$\text{From balanced equation: } \frac{n_a}{n_b} = \frac{1}{2} \therefore n_a = \frac{1}{2} n_b = \frac{1}{2} (8,57 \times 10^{-3}) = 4,29 \times 10^{-3} \text{ mol}$$

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

9.2



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



$$\text{pH} = -\log[\text{H}_3\text{O}^+] = 4$$

$$\therefore [\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-4} = 1 \times 10^{-4} \text{ mol}\cdot\text{dm}^{-3}$$

$$n_a = c_a V_a = (1 \times 10^{-4})(1) = 1 \times 10^{-4} \text{ mol}$$

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

$$\text{Mass CaCO}_3: n = \frac{m}{M} \therefore 0,5 \times 10^{-4} = \frac{m}{106} \therefore m = 5,3 \times 10^{-3} \text{ g}$$

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