education

DEPARTMENT: EDUCATION
MPUMALANGA PROVINCE

GERT SIBANDE DISTRICT

GRADE 11

PHYSICAL SCIENCES TOPIC TEST

TOPIC: ACIDS AND BASES

SEPTEMBER 2023

MARKS: 50

TIME: 1Hour

**This question paper consists of 8 pages including the data sheets**

INSTRUCTIONS AND INFORMATION

1. This question paper consists of FOUR questions. Answer ALL the questions in

    the ANSWER BOOK.

2. Start EACH question on a NEW page in the ANSWER BOOK.

3. Number the answers correctly according to the numbering system used in this

    question paper.

4. Leave ONE line between two sub questions, for example between QUESTION

    2.1 and QUESTION 2.2.

5. You may use a non-programmable calculator.

6. You may use appropriate mathematical instruments.

7. You are advised to use the attached DATA SHEETS.

8. Show ALL formulae and substitutions in ALL calculations.

9. Round off your final numerical answers to a minimum of TWO decimal places.

10. Give brief motivations, discussions et cetera where required.

11. Write neatly and legibly.

QUESTION 1

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A – D) next to the question numbers (1.1 – 1.5) in the answer book, eg .6 E

1.1 Consider the following chemical reaction:

$$HCO_3^- + HC_2O_4^- \rightleftharpoons H_2CO_3 + C_2O_4^{2-}$$
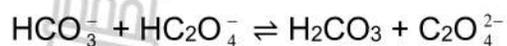
Which ONE of the following CORRECTLY identifies the order of Lowry-Bronsted acids and bases in the above reaction?

A   Acid, base, base, acid.

B   Base, acid, acid, base.

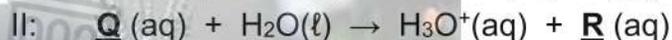C   Acid, base, acid, base.

D   Base, acid, base, acid.   (2)

1.2 Which ONE of the following species CANNOT act as a Brønsted-Lowry acid and a Brønsted-Lowry base?

A CH_3COOH

B H_2O

C HSO_4^-

D $H_2PO_4^-$ (2)

1.3 The compound which will react with sodium hydroxide ($NaOH$) in a neutralisation reaction is……

A   KOH

B $CaCO_3$

C $C_2O_4^{2-}$

D CH_3COOH (2)

3

1.4 When sulfuric acid reacts with water, it ionises in two steps, as shown in the two balanced equations below.
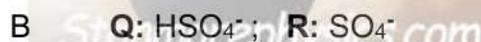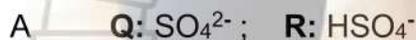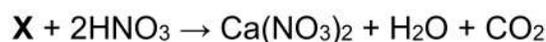
I: $H_2SO_4(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) + \underline{Q}(aq)$

II: $\underline{Q}(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) + \underline{R}(aq)$
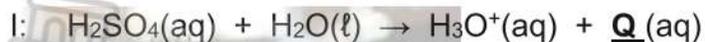
The species represented by letters **Q** and **R** are…….

A   **Q:** SO_4^{2-} ;   **R:** HSO_4^-

B   **Q:** HSO_4^- ;   **R:** SO_4^-

C   **Q:** HSO_4^- ;   **R:** SO_4^{2-}

D   **Q:** HSO_4^{2-} ;   **R:** SO_4^- (2)

1.5 Consider the incomplete chemical equation below.

$X + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$

Which ONE of the following is represented by **X** in the above equation?

A $Ca(OH)_2$

B CaO

C $CaHCO_3$

D $CaCO_3$ (2)

[10]

QUESTION 2

2.1 Consider the following acid-base reaction:

$HCO_3^-(aq) + NH_3(aq) \rightarrow CO_3^{2-}(aq) + NH_4^+(aq)$
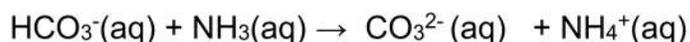
2.1.1 Define *an acid in* terms of the Lowry-Bronsted theory.   (2)

2.1.2 Write down the FORMULAE of the TWO acids in the above reaction.   (2)

2.1.3 Define the term ampholyte.   (2)

2.1.4 Write down the formula of an ampholyte in the above reaction.   (1)

2.1.5 Write down a balanced chemical equation to show how the ampholyte named in question 2.1.4 above reacts with water, in which water acts as an acid.   (3)

2.2 CO_3^{2-} (aq) in the above reaction is reacted with 20cm^3 of 0,2 mol.dm^{-3}

hydrochloric acid, according to the following balanced equation.

$$HCl(aq) + CO_3^{2-}(aq) \rightarrow Cl^-(aq) + HCO_3^-(aq)$$

2.2.1 Write down a reason why Cl^-(aq) is referred to as a base.

(1)

2.2.2 Calculate the number of moles of hydrochloric acid reacted.

(3)
[14]

QUESTION 3

3.1 Two acid-base reactions are shown in the chemical equations below.

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

(ii) $HPO_4^{2-}(aq) + H_2O(l) \rightarrow PO_4^{3-}(aq) + H_3O^+(aq)$
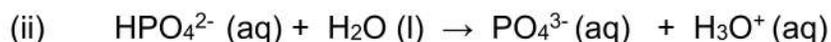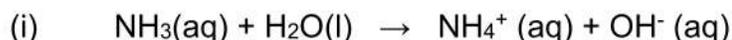
3.1.1 Define a base according to Arrhenius theory. (2)

Write down the FORMULA of:

3.1.2 A conjugate acid of OH^- (aq) in reaction(i). (1)

3.1.3 A conjugate base of HPO_4^{2-} (aq) in reaction(ii). (1)

Methyl orange indictor is added to the mixture in reaction (i) above at the completion of the reaction. The colour change of methyl orange indictor in acidic and basic solutions is shown in the table below.

COLOUR IN ACIDIC SOLUTION	COLOUR IN BASIC SOLUTION
Red	Yellow

3.1.4 Define the term *acid-base indicator*. (2)

3.1.5 What is the colour of the indicator in the reaction mixture?

Give a reason for the answer.
(2)

3.2 Write down a balanced equation for the dissolution of ethanoic acid,

CH_3COOH(aq) in water.   check if in ATP

(3)
[11]

QUESTION 4

4.1 The Bronsted-Lowry and Arrhenius theories are used to define acids and bases.

    4.1.1 Define a base according to Bronsted-Lowry theory.   (2)

    Consider the following chemical reactions:

        A: $NaOH\ (aq)\ + CH_3COOH\ (aq) \rightleftharpoons CH_3COONa\ (aq) + H_2O\ (l)$

        B: $NH_4^+\ (aq) + HSO_4^-\ (aq) + \rightleftharpoons NH_3(aq) + H_2SO_4\ (aq)$

        C: $HSO_4^-\ (aq) \rightleftharpoons H^+\ (aq) + SO_4^{2-}\ (aq)$
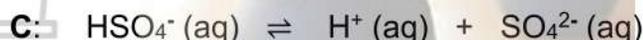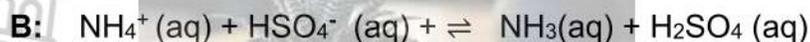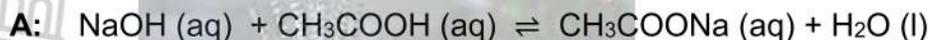
    From the reactions **A**, **B** and **C**, write down:

    4.1.2 The reaction that illustrates Arrhenius theory.   (1)

    4.1.3 A substance that can act as an ampholyte.   ((1)

    4.1.4 A conjugate acid-base pair in reaction **C**.   (2)

4.2 Grade 11 learners uses two steps to react sodium carbonate, $Na_2CO_3(aq)$ with concentrated sulphuric acid, $H_2SO_4(aq)$.

    In **STEP 1**: They prepare a 250 cm^3 standard solution by dissolving 5.13 g Na_2CO_3 crystals in distilled water.

    In **STEP 2**: They reacted the prepared $Na_2CO_3(aq)$ with $H_2SO_4(aq)$.
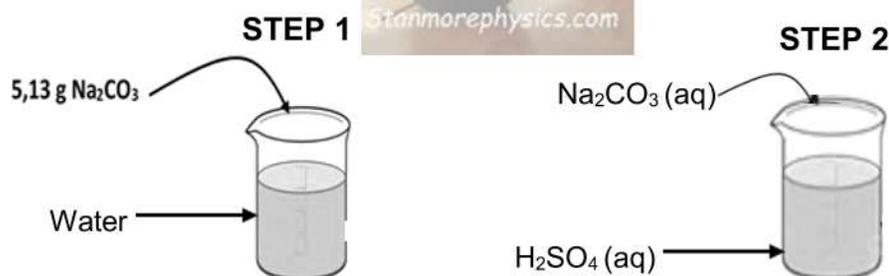
The reaction occurs according to the following balanced equation.

$$Na_2CO_3\ (aq) + H_2SO_4\ (aq) \longrightarrow Na_2SO_4\ (aq) + H_2O\ (l) + CO_2\ (g)$$

    4.2.1 Define *acid* according to Arrhenius theory.   (2)

    Calculate:

    4.2.2 The concentration of $Na_2CO_3(aq)$ in the standard solution.   (3)

    4.2.3 The number of moles of $H_2SO_4(aq)$ reacted.   (4)

                                 TOTAL:50 **[15]**

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Standard pressure	p^θ	$1,013 \times 10^5$ Pa
Molar gas volume at STP	V_m	$22,4$ dm^3·mol^{-1}
Standard temperature	T^θ	273 K
Charge on electron	e	$-1,6 \times 10^{-19}$ C

TABLE 2: FORMULAE

$n = \dfrac{m}{M}$	$n = \dfrac{N}{N_A}$
$c = \dfrac{n}{V}$ OR $c = \dfrac{m}{MV}$	$n = \dfrac{V}{V_m}$

TABLE 3: THE PERIODIC TABLE OF ELEMENTS

KEY

Electronegativity →	1,9
Atomic number →	29
Symbol →	Cu
Relative atomic mass (approximately) →	63,5

Each cell below is given as: **Electronegativity** / **Atomic number** / **Symbol** / **Relative atomic mass**

I	II	III	IV	V	VI	VII	VIII	VIII	VIII	I	II	III	IV	V	VI	VII	0
2,1 / 1 / H / 1																	2 / He / 4
1,0 / 3 / Li / 7	1,5 / 4 / Be / 9											2,0 / 5 / B / 11	2,5 / 6 / C / 12	3,0 / 7 / N / 14	3,5 / 8 / O / 16	4,0 / 9 / F / 19	10 / Ne / 20
0,9 / 11 / Na / 23	1,2 / 12 / Mg / 24											1,5 / 13 / Aℓ / 27	1,8 / 14 / Si / 28	2,1 / 15 / P / 31	2,5 / 16 / S / 32	3,0 / 17 / Cℓ / 35,5	18 / Ar / 40
0,8 / 19 / K / 39	1,0 / 20 / Ca / 40	1,3 / 21 / Sc / 45	1,5 / 22 / Ti / 48	1,6 / 23 / V / 51	1,6 / 24 / Cr / 52	1,5 / 25 / Mn / 55	1,8 / 26 / Fe / 56	1,8 / 27 / Co / 59	1,8 / 28 / Ni / 59	1,9 / 29 / Cu / 63,5	1,6 / 30 / Zn / 65	1,6 / 31 / Ga / 70	1,8 / 32 / Ge / 73	2,0 / 33 / As / 75	2,4 / 34 / Se / 79	2,8 / 35 / Br / 80	36 / Kr / 84
0,8 / 37 / Rb / 86	1,0 / 38 / Sr / 88	1,2 / 39 / Y / 89	1,4 / 40 / Zr / 91	1,6 / 41 / Nb / 92	1,8 / 42 / Mo / 96	1,9 / 43 / Tc /	2,2 / 44 / Ru / 101	2,2 / 45 / Rh / 103	2,2 / 46 / Pd / 106	1,9 / 47 / Ag / 108	1,7 / 48 / Cd / 112	1,7 / 49 / In / 115	1,8 / 50 / Sn / 119	1,9 / 51 / Sb / 122	2,1 / 52 / Te / 128	2,5 / 53 / I / 127	54 / Xe / 131
0,7 / 55 / Cs / 133	0,9 / 56 / Ba / 137	1,1 / 57 / La / 139	1,6 / 72 / Hf / 179	73 / Ta / 181	74 / W / 184	75 / Re / 186	76 / Os / 190	77 / Ir / 192	78 / Pt / 195	79 / Au / 197	1,7 / 80 / Hg / 201	1,8 / 81 / Tℓ / 204	1,8 / 82 / Pb / 207	1,9 / 83 / Bi / 209	2,0 / 84 / Po /	2,5 / 85 / At /	86 / Rn /
0,7 / 87 / Fr /	0,9 / 88 / Ra / 226	89 / Ac /															

Lanthanides

58 / Ce / 140	59 / Pr / 141	60 / Nd / 144	61 / Pm /	62 / Sm / 150	63 / Eu / 152	64 / Gd / 157	65 / Tb / 159	66 / Dy / 163	67 / Ho / 165	68 / Er / 167	69 / Tm / 169	70 / Yb / 173	71 / Lu / 175

Actinides

90 / Th / 232	91 / Pa /	92 / U / 238	93 / Np /	94 / Pu /	95 / Am /	96 / Cm /	97 / Bk /	98 / Cf /	99 / Es /	100 / Fm /	101 / Md /	102 / No /	103 / Lr /

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TOPIC: ACIDS AND BASES

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Marking guidelines

MARKS: 50

These marking guidelines consist of 4 pages

QUESTION 1

1.1   B ✓✓   (2)

1.2   A ✓✓   (2)

1.3   D ✓✓   (2)

1.4   C ✓✓   (2)

1.5   D ✓✓   (2)

                                                                                       [10]

QUESTION 2

2.1.1   Proton donor/H^+ ion donor ✓✓   (2)

2.1.2 HCO_3^- and NH_4^+ ✓✓   (2)

2.1.3   Substance that can act as both an acid and a base. ✓✓   (2)

2.1.4 HCO_3^- ✓   (1)

2.1.5 $HCO_3^- + H_2O$ ✓ $\rightarrow$ $H_2CO_3 + OH^-$ ✓ (**bal** : ✓)   (3)

2.2.1   Accepts a proton/H^+ ion. ✓   (1)

2.2.2 $n = CV$ ✓

         $n = 0{,}2 \times 0{,}02$ ✓

         $n = 0{,}004$ mol ✓   (3)

                                                                                       [14]

2

QUESTION 3

3.1.1 A substance that produces hydroxide ions/OH^- ions when dissolved in water. ✓✓ (2)

3.1.2 H_2O ✓ (1)

3.1.3 PO_4^{3-} ✓ (1)

3.1.4 A weak acid or a weak base, which colour changes as the H^+ ion concentration or the OH- ion concentration in a solution changes ✓✓ (2)

[2 or 0 mark]

3.1.5 YELLOW ✓

Solution is basic/ solution contains OH^- ions. ✓ (2)

3.2 $CH_3COOH + H_2O$ ✓ $\rightarrow CH_3COO^- + H_3O^+$ ✓ (Bal:✓) (3)

[11]

QUESTION 4

4.1.1 A proton acceptor/ H^+ ion acceptor. ✓✓ (2)

4.1.2 C ✓ (1)

4.1.3 HSO_4^- ✓ (1)

4.1.4 <u>HSO_4^- and SO_4^{2-}</u> ✓✓ (2)

4.2.1 A substance that produces hydrogen ions(H^+) ions/ hydronium(H_3O^+) ions when dissolved in water. ✓✓ (2)

4.2.2 $C(Na_2CO_3) = \dfrac{m}{MV}$ ✓

$C(Na_2CO_3) = \dfrac{5,13}{(106)(0,25)}$ ✓

$C(Na_2CO_3) = 0,194 \text{ mol.dm}^{-3}$ ✓ (3)

4.2.3

OPTION 1	OPTION 2
$n(Na_2CO_3) = CV$ $n(Na_2CO_3) = 0,194 \times 0,25$ ✓ $n(Na_2CO_3) = 0,0485$ mol ✓ $n(Na_2CO_3) = n(H_2SO_4)$ ✓ $n(H_2SO_4) = 0,0485$ mol ✓	$n(Na_2CO_3) = \dfrac{m}{M}$ $n(Na_2CO_3) = \dfrac{5,13}{106}$ ✓ $n(Na_2CO_3) = 0,0485$ mol ✓ $n(Na_2CO_3) = n(H_2SO_4)$ ✓ $n(H_2SO_4) = 0,0485$ mol ✓

(4)

[15]

TOTAL: 50