basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

PHYSICAL SCIENCES: CHEMISTRY (P2)

2023

MARKS: 150

TIME: 3 hours

This question paper consists of 16 pages and 4 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the appropriate spaces on the ANSWER BOOK.

2. This question paper consists of NINE questions. Answer ALL the questions in the ANSWER BOOK.

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

4. Number the answers correctly according to the numbering system used in this question paper.

5. Leave ONE line between two subquestions, e.g. between QUESTION 2.1 and QUESTION 2.2.

6. You may use a non-programmable calculator.

7. You may use appropriate mathematical instruments.

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, etc. where required.

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

12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various 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 to 1.10) in the ANSWER BOOK, e.g. 1.11 E.

1.1 For which ONE of the following molecular formulae are CHAIN isomers possible?

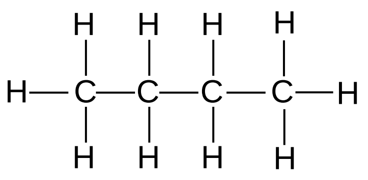
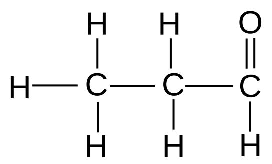
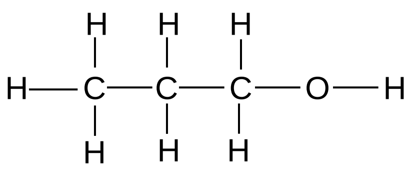
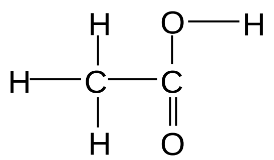
A C_4H_{10}

B C_3H_8

C C_2H_6O

D C_3H_8O (2)

1.2 Which ONE of the following compounds has the LOWEST vapour pressure under the same conditions?

A		B	
C		D	

(2)

1.3 The type of organic compound formed when a haloalkane is heated in the presence of a concentrated strong base is an …

A alkane.

B alkene.

C alkyne.

D alcohol. (2)

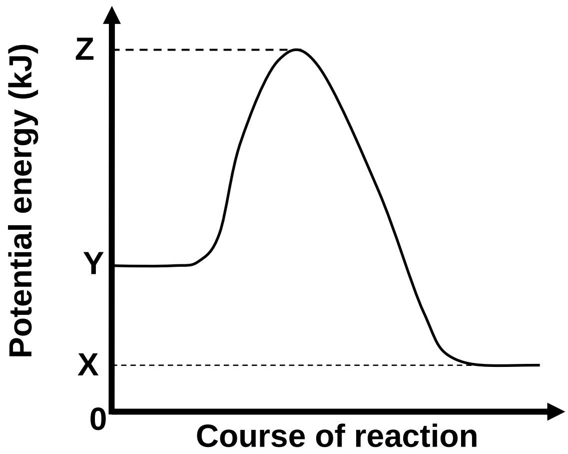
1.4 EXCESS HCℓ(aq) of concentration 0,1 mol·dm^{-3} reacts with 2 g of Mg under different conditions.

Which ONE of the following combinations of conditions will produce the largest volume of H_2(g) in the FIRST MINUTE of the reaction?

	STATE OF DIVISION OF Mg	**TEMPERATURE OF HCℓ(aq) (°C)**
A	Powder	20
B	Granules	20
C	Powder	50
D	Granules	50

(2)

1.5 The potential energy diagram for a chemical reaction is shown below.



Which ONE of the following combinations is CORRECT for the FORWARD reaction?

	ΔH	**ACTIVATION ENERGY**	**POTENTIAL ENERGY OF THE ACTIVATED COMPLEX**
A	**Y–X**	**Z+Y**	**Z**
B	**Y–X**	**Z–Y**	**Z+Y**
C	**X–Y**	**Z–Y**	**Z**
D	**X–Y**	**Z**	**Z–Y**

(2)

1.6 Consider the following reaction that reaches equilibrium in a beaker:

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(\ell)$$

A few drops of concentrated NaOH(aq) are now added to the beaker.

Which ONE of the following combinations correctly identifies the DISTURBANCE ON THE SYSTEM and the SYSTEM'S RESPONSE to the disturbance?

	DISTURBANCE ON THE SYSTEM	SYSTEM'S RESPONSE
A	$[H^+]$ decreases	Forward reaction favoured
B	$[H^+]$ decreases	Reverse reaction favoured
C	$[CrO_4^{2-}]$ decreases	Reverse reaction favoured
D	$[CrO_4^{2-}]$ increases	Forward reaction favoured

(2)

1.7 According to the Lowry-Brønsted theory, a conjugate base is formed when a/an …

A proton is added to the acid.

B electron is added to the acid.

C proton is removed from the acid.

D electron is removed from the acid. (2)

1.8 Consider the statements below regarding an alkaline substance.

An alkaline substance:

(i) Reacts with an acid to form a neutral solution

(ii) Turns red litmus blue

(iii) Forms a salt when it reacts with an acid

Which of the statements above are ALWAYS TRUE?

A (i), (ii) and (iii)

B (i) and (ii) only

C (i) and (iii) only

D (ii) and (iii) only (2)

1.9 Consider the cell notation for a galvanic cell.

$$Pt \mid H_2(g) \mid OH^-(aq) \mid H_2O(\ell) \parallel Ag^+(aq) \mid Ag(s)$$

Which ONE of the following equations represents the half-reaction taking place at the positive electrode?

A $Ag^+(aq) + e^- \rightarrow Ag(s)$

B $Ag(s) \rightarrow Ag^+(aq) + e^-$

C $2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

D $H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(\ell) + 2e^-$ (2)

1.10 A concentrated solution of sodium chloride, $NaC\ell(aq)$, undergoes electrolysis.

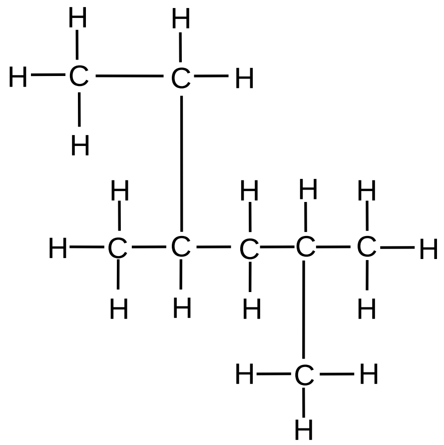
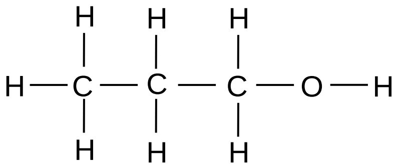
Which ONE of the combinations correctly shows the products formed at each electrode?

	CATHODE	ANODE
A	Na	$C\ell_2$
B	H_2	OH^-
C	$C\ell_2$	H_2 and OH^-
D	H_2 and OH^-	$C\ell_2$

(2)
[20]

QUESTION 2 (Start on a new page.)

Study the table below and answer the questions that follow.

A		**B**	
C	C_4H_8O	**D**	$CH_3(CH_2)_4CHCH_2$
E	$C_XH_YO_Z$		

2.1 Define the term *unsaturated* hydrocarbon. (2)

2.2 Write down the:

2.2.1 Letter that represents an UNSATURATED hydrocarbon (1)

2.2.2 IUPAC name of compound **A** (3)

2.2.3 IUPAC name of the POSITIONAL isomer of compound **B** (2)

2.2.4 IUPAC name of compound **D** (2)

2.2.5 Balanced equation, using MOLECULAR FORMULAE, for the complete combustion of compound **A** (3)

2.3 The formula C_4H_8O represents two compounds that are functional isomers of each other.

2.3.1 Define the term *functional isomer*. (2)

2.3.2 Write down the STRUCTURAL FORMULAE of each of these two FUNCTIONAL isomers. (4)

2.4 A 2 g sample of compound **E** contains 1,09 g carbon and 0,18 g hydrogen. The molecular mass of compound **E** is 88 g·mol^{-1}.

Determine the molecular formula of compound **E** by means of a calculation. (6)
[25]

QUESTION 3 (Start on a new page.)

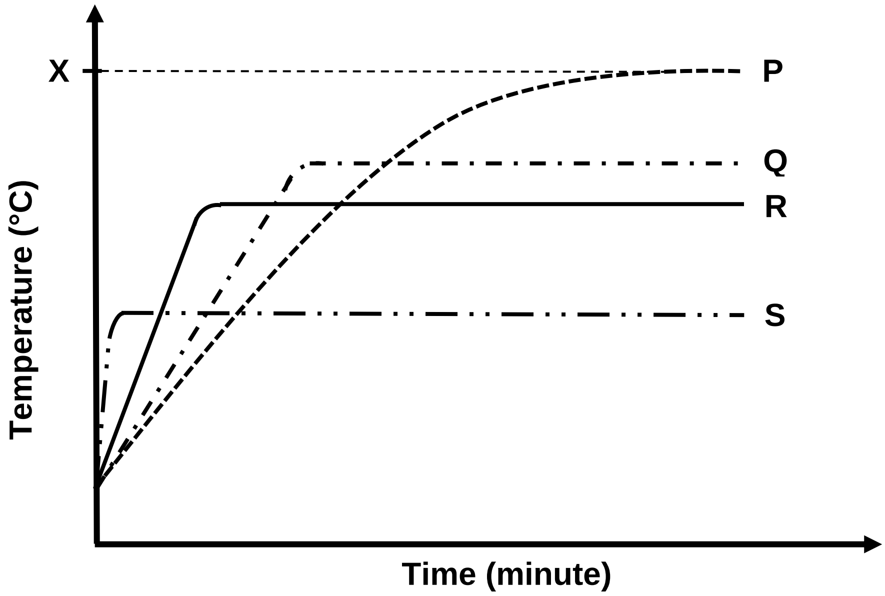
Learners investigate the boiling points of the four organic compounds given below.

ORGANIC COMPOUND	MOLECULAR MASS ($g \cdot mol^{-1}$)
Butanone	72
Butan-1-ol	74
Propanoic acid	74
2-methylpropan-1-ol	74

3.1 Define the term *boiling point.* (2)

3.2 Which compound, butan-1-ol or 2-methylpropan-1-ol, will have the higher boiling point? Fully explain the answer. (4)

The curves **P**, **Q**, **R** and **S** below were obtained from the results of the investigation. **X** represents a specific temperature.



3.3 Which physical property is represented by temperature **X**? (1)

3.4 Which curve (**P**, **Q**, **R** or **S**) represents:

3.4.1 Butanone (1)

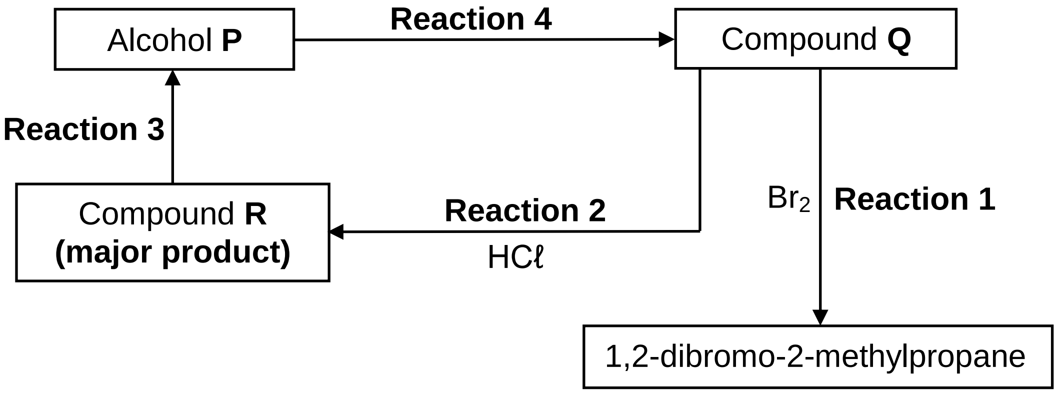
3.4.2 Propanoic acid (1)

3.4.3 2-methylpropan-1-ol (1)

3.5 Give a reason for the answer to QUESTION 3.4.2. (1)
[11]

QUESTION 4 (Start on a new page.)

4.1 The flow diagram below shows different organic reactions.
P, **Q** and **R** are organic compounds.



Reaction 1 is an addition reaction.

Write down:

4.1.1 The TYPE of addition reaction (1)

4.1.2 ONE observable change which occurs in the container during the reaction (1)

4.1.3 The STRUCTURAL FORMULA of compound **Q** (2)

Consider **reaction 2**.

4.1.4 Write down the IUPAC name of compound **R**. (2)

For **reaction 3**, write down:

4.1.5 A balanced equation using STRUCTURAL FORMULAE for the organic compounds (6)

4.1.6 The IUPAC name of alcohol **P** (2)

Reaction 4 is an elimination reaction.

4.1.7 Write down the TYPE of elimination reaction. (1)

4.2 Butan-1-ol reacts with propanoic acid in the presence of a catalyst.

Write down the:

4.2.1 TYPE of reaction that takes place (1)

4.2.2 IUPAC name of the organic product formed (2)
[18]

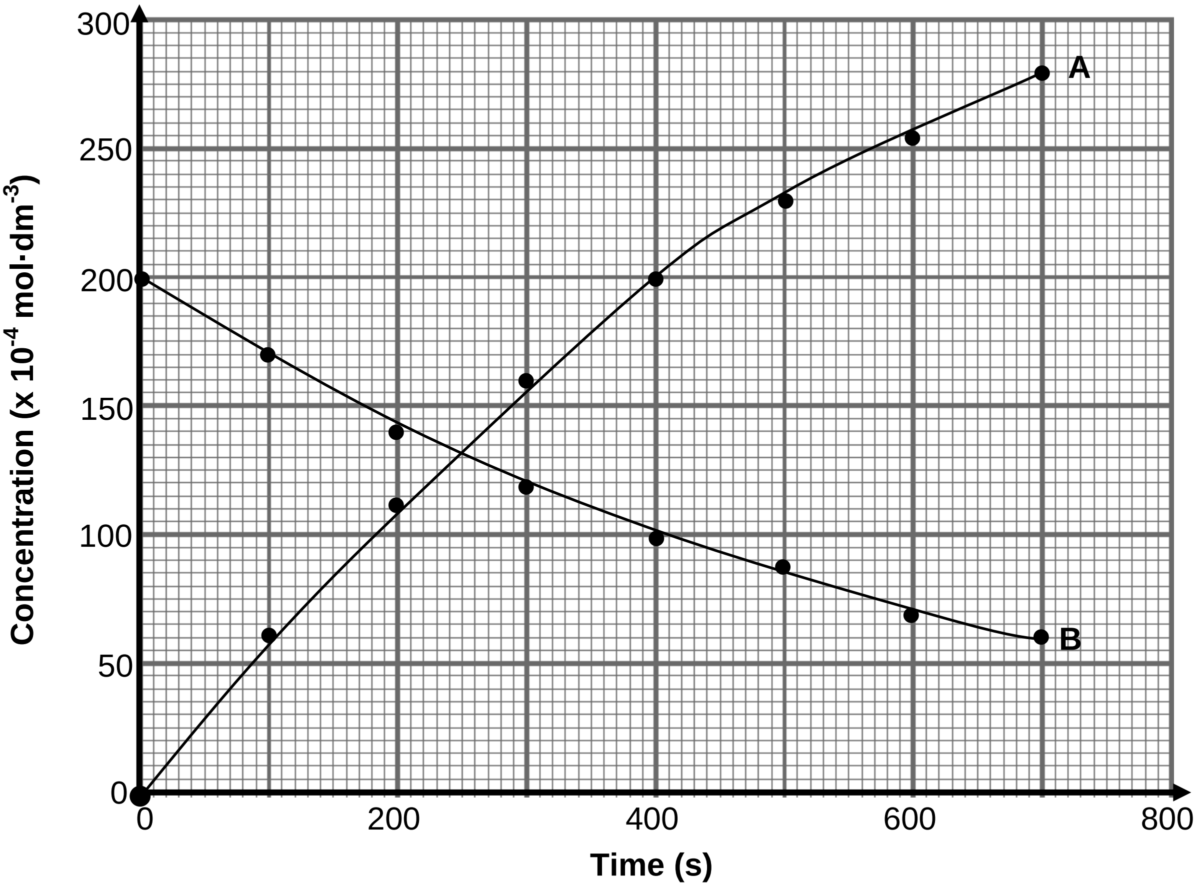
QUESTION 5 (Start on a new page.)

Consider the following decomposition reaction that takes place in a sealed 2 dm^3 container:

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

The graph below shows how the concentrations of $N_2O_5(g)$ and $NO_2(g)$ change with time.

Concentration-time graph



5.1 Refer to the graph above and give a reason why curve **A** represents the change in the concentration of $NO_2(g)$. (1)

5.2 Consider the statement below:

The rate of decomposition of $N_2O_5(g)$ is half the rate of formation of $NO_2(g)$.

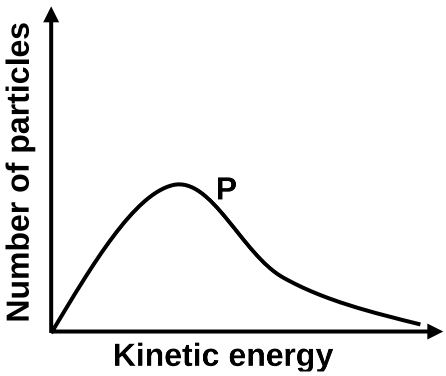
Is this statement TRUE or FALSE? Give a reason for the answer. (2)

5.3 Calculate the:

5.3.1 Mass of NO_2(g) present in the container at 400 s (4)

5.3.2 Average rate of production of O_2(g) in $mol \cdot dm^{-3} \cdot s^{-1}$ in 700 s (4)

5.4 The Maxwell-Boltzmann distribution curve for the N_2O_5(g) initially present in the container is shown below.



The initial concentration of the N_2O_5(g) is now INCREASED.

5.4.1 Redraw the distribution curve above in the ANSWER BOOK and label this curve as **P**.

On the same set of axes, sketch the curve that will be obtained for the higher concentration of N_2O_5(g). Label this curve as **Q**. (2)

5.4.2 Will the rate of decomposition of N_2O_5(g) at the higher concentration be HIGHER THAN, LOWER THAN or EQUAL TO the original rate of decomposition? Explain the answer using the collision theory. (3)

[16]

QUESTION 6 (Start on a new page.)

One mole of pure hydrogen iodide gas, HI(g), is sealed in a 1 dm^3 container at 721 K. Equilibrium is reached according to the following balanced equation:

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

It is found that 0,11 moles of $I_2(g)$ are present at equilibrium.

6.1 State Le Chatelier's principle. (2)

6.2 Determine the number of moles of EACH of the following at equilibrium:

6.2.1 $H_2(g)$ (1)

6.2.2 HI(g) (1)

6.3 The equilibrium constant, K_c, at 721 K is 0,02.

The temperature of the container is now increased to 850 K.
The equilibrium constant, K_c, at 850 K is 0,09.

6.3.1 Is the forward reaction EXOTHERMIC or ENDOTHERMIC? (1)

6.3.2 Fully explain the answer to QUESTION 6.3.1. (3)

6.3.3 Calculate the mass of HI(g) present at the new equilibrium at 850 K. (8)

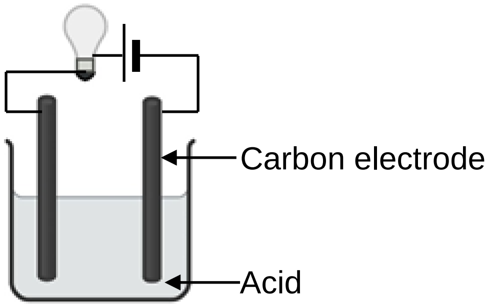
[16]

QUESTION 7 (Start on a new page.)

7.1 The conductivity of three acid solutions, **A**, **B** and **C**, as shown below is investigated at the same temperature.

A	0,1 mol·dm^{-3} H_2SO_4(aq)
B	0,1 mol·dm^{-3} HNO_3(aq)
C	0,1 mol·dm^{-3} CH_3COOH(aq)

The brightness of the bulb in the apparatus shown below is used as a measure of the conductivity of the solutions.



The acid solutions are electrolytes.

7.1.1 Define the term *electrolyte*. (2)

The brightness of the bulb for each of the solutions is compared.

7.1.2 In which solution, **A** or **B**, will the bulb be brighter? Give a reason for the answer by referring to the types of acids. (2)

7.1.3 In which solution, **B** or **C**, will the bulb be brighter? Give a reason for the answer by referring to the types of acids. (2)

7.2 A hydrochloric acid solution, HCℓ(aq), is standardised by titrating it against 25 cm^3 of a 0,04 mol·dm^{-3} sodium carbonate solution Na_2CO_3(aq). At the endpoint, it is found that 19,5 cm^3 of HCℓ(aq) has reacted.

The balanced equation for the reaction is:

$$Na_2CO_3(aq) + 2HC\ell(aq) \rightarrow 2NaC\ell(aq) + CO_2(g) + H_2O(\ell)$$

7.2.1 Calculate the concentration of the HCℓ(aq). (3)

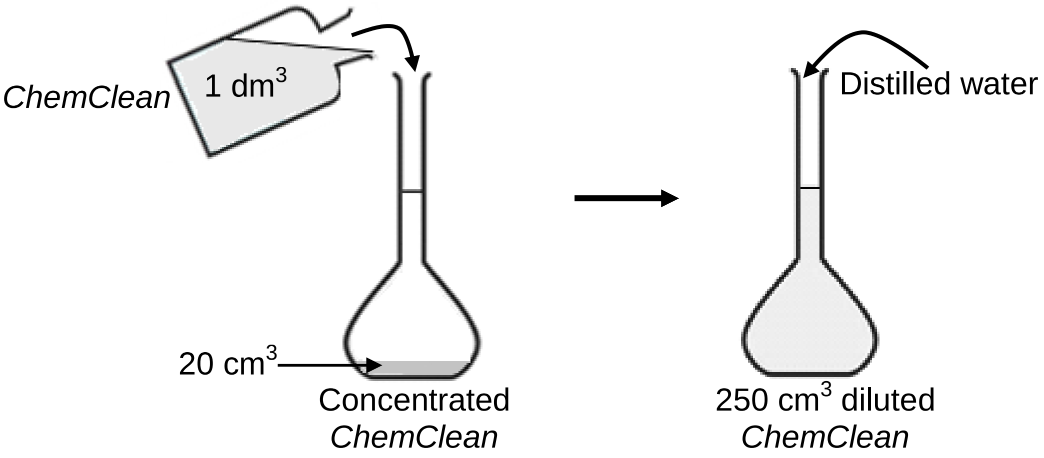
7.2.2 Suppose a few drops of water were present in the burette before it was filled with the hydrochloric acid solution.

How will the volume of the HCℓ solution needed to reach the endpoint be affected?

Choose from GREATER THAN, SMALLER THAN or REMAINS THE SAME. Give a reason for the answer. (2)

A concentrated household product, *ChemClean*, contains ammonia as the main cleaning agent. To determine the amount of ammonia present in 1 dm^3 of *ChemClean*, the following procedure is followed:

20 cm^3 of *ChemClean* is added to a 250 cm^3 flask. The flask is then filled to the 250 cm^3 mark with distilled water.



The diluted solution is titrated against the hydrochloric acid solution of the concentration as calculated in QUESTION 7.2.1.

During the titration, 22 cm^3 of the diluted *ChemClean* solution is neutralised by 18,7 cm^3 of the HCℓ solution. The balanced equation for the reaction is:

$$NH_3(aq) + HC\ell(aq) \rightarrow NH_4^+(aq) + C\ell^-(aq)$$

7.2.3 Calculate the mass of ammonia in 1 dm^3 of *ChemClean*. (7)

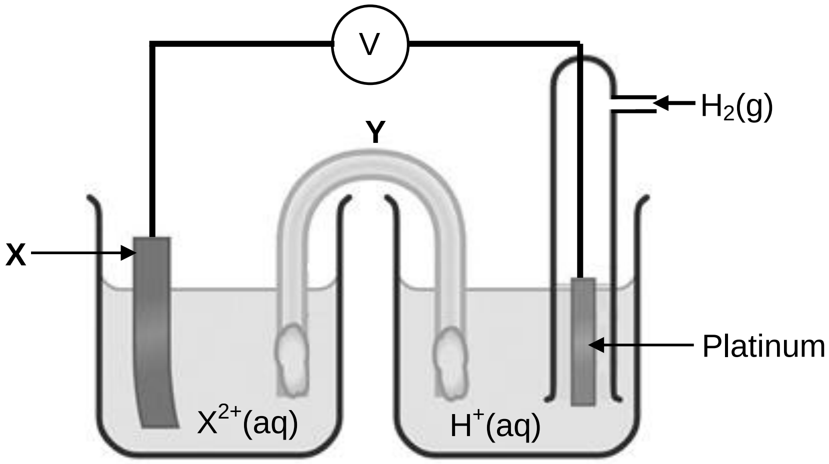
7.2.4 Will the pH of the solution at the end of the titration be GREATER THAN 7, EQUAL TO 7 or LESS THAN 7?

Write down the relevant equation as motivation for the answer. (3)
[21]

QUESTION 8 (Start on a new page.)

Learners want to identify an unknown metal **X** using a standard half-cell, $X | X^{2+}$.

They set up an electrochemical cell under standard conditions using two half-cells, as shown in the diagram below.



The initial emf of this cell is 1,20 V.

8.1 State the standard conditions under which this cell functions. (3)

8.2 State ONE function of component **Y**. (1)

After the cell has operated for some time, it is found that the mass of electrode **X** has increased.

8.3 Identify **X** by means of a suitable calculation. (5)

8.4 Write down the oxidation half-reaction that takes place in this cell. (2)

Half-cell $X | X^{2+}$ is now replaced by an $Au | Au^{3+}$ half-cell.

The initial emf of the cell is now 1,50 V. As the cell operates, the Au electrode increases in mass.

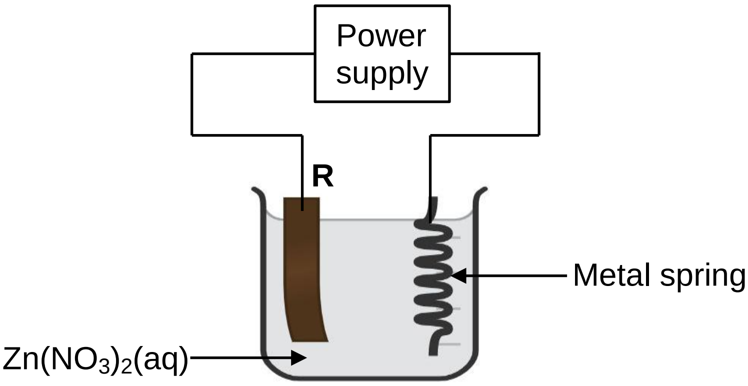
8.5 Arrange the oxidising agents, X^{2+}, Au^{3+} and H^+, in order of increasing strength.

Fully explain the answer. (3)

[14]

QUESTION 9 (Start on a new page.)

The simplified electrolytic cell below is used to electroplate a metal spring. Zinc nitrate, $Zn(NO_3)_2(aq)$, is used as an electrolyte and **R** is an electrode.



9.1 Define the term *electrolytic cell.* (2)

9.2 Which electrode (**R** or **METAL SPRING**) is the ANODE? Give a reason for the answer. (2)

9.3 Write down the:

9.3.1 Equation for the half-reaction occurring at the metal spring (2)

9.3.2 NAME or FORMULA of a suitable metal that can be used as electrode **R** (1)

9.4 Explain the answer to QUESTION 9.3.2. (2)
[9]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^{θ}	$1{,}013 \times 10^{5}$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	$22{,}4\ dm^{3}\cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K
Charge on electron *Lading op elektron*	e	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}\ mol^{-1}$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ / $E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ / $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{oxidising agent} - E^{\theta}_{reducing agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	
$I = \frac{Q}{\Delta t}$	$n = \frac{Q}{q_e}$ where n = number of electrons

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/*SLEUTEL*

Atomic number / *Atoomgetal* → 29

Electronegativity / *Elektronegatiwiteit* → 1,9

Symbol / *Simbool* → Cu

Approximate relative atomic mass / *Benaderde relatiewe atoommassa* → 63,5

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

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
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

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD-REDUKSIEPOTENSIALE

Increasing strength of oxidising agents /*Toenemende sterkte van oksideermiddels* ↑

Increasing strength of reducing agents /*Toenemende sterkte van reduseermiddels* ↓

Half-reactions/*Halfreaksies*			E^θ (V)
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 2,87
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	$2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	+ 1,51
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	$\rightleftharpoons$	Pt	+ 1,20
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 0,85
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	+ 0,80
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O_2	+ 0,68
$I_2 + 2e^-$	$\rightleftharpoons$	$2I^-$	+ 0,54
$Cu^+ + e^-$	$\rightleftharpoons$	Cu	+ 0,52
$SO_2 + 4H^+ + 4e^-$	$\rightleftharpoons$	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons$	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	$\rightleftharpoons$	Cu^+	+ 0,16
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	+ 0,15
$S + 2H^+ + 2e^-$	$\rightleftharpoons$	$H_2S(g)$	+ 0,14
$\mathbf{2H^+ + 2e^-}$	$\rightleftharpoons$	$\mathbf{H_2(g)}$	**0,00**
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	− 0,06
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	− 0,13
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	− 0,14
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	− 0,27
$Co^{2+} + 2e^-$	$\rightleftharpoons$	Co	− 0,28
$Cd^{2+} + 2e^-$	$\rightleftharpoons$	Cd	− 0,40
$Cr^{3+} + e^-$	$\rightleftharpoons$	Cr^{2+}	− 0,41
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	Fe	− 0,44
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	Cr	− 0,74
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	− 0,76
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	− 0,83
$Cr^{2+} + 2e^-$	$\rightleftharpoons$	Cr	− 0,91
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	− 1,18
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	− 1,66
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	Mg	− 2,36
$Na^+ + e^-$	$\rightleftharpoons$	Na	− 2,71
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	Ca	− 2,87
$Sr^{2+} + 2e^-$	$\rightleftharpoons$	Sr	− 2,89
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	Ba	− 2,90
$Cs^+ + e^-$	$\rightleftharpoons$	Cs	- 2,92
$K^+ + e^-$	$\rightleftharpoons$	K	− 2,93
$Li^+ + e^-$	$\rightleftharpoons$	Li	− 3,05

TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARD-REDUKSIEPOTENSIALE

Increasing strength of oxidising agents /*Toenemende sterkte van oksideermiddels* (↓)

Increasing strength of reducing agents /*Toenemende sterkte van reduseermiddels* (↑)

Half-reactions/*Halfreaksies*			**E^θ (V)**
$Li^+ + e^-$	⇌	Li	− 3,05
$K^+ + e^-$	⇌	K	− 2,93
$Cs^+ + e^-$	⇌	Cs	− 2,92
$Ba^{2+} + 2e^-$	⇌	Ba	− 2,90
$Sr^{2+} + 2e^-$	⇌	Sr	− 2,89
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Na^+ + e^-$	⇌	Na	− 2,71
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 1,66
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76
$Cr^{3+} + 3e^-$	⇌	Cr	− 0,74
$Fe^{2+} + 2e^-$	⇌	Fe	− 0,44
$Cr^{3+} + e^-$	⇌	Cr^{2+}	− 0,41
$Cd^{2+} + 2e^-$	⇌	Cd	− 0,40
$Co^{2+} + 2e^-$	⇌	Co	− 0,28
$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$2H^+ + 2e^-$	**⇌**	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

SENIORSERTIFIKAAT-EKSAMEN/ NASIONALE SENIORSERTIFIKAAT-EKSAMEN

PHYSICAL SCIENCES: CHEMISTRY (P2)
FISIESE WETENSKAPPE: CHEMIE (V2)

2023

MARKING GUIDELINES/*NASIENRIGLYNE*

MARKS/*PUNTE*: 150

These marking guidelines consist of 20 pages.
Hierdie nasienriglyne bestaan uit 20 bladsye.

QUESTION/*VRAAG 1*

1.1 A ✓✓ (2)

1.2 D ✓✓ (2)

1.3 B ✓✓ (2)

1.4 C ✓✓ (2)

1.5 C ✓✓ (2)

1.6 B ✓✓ (2)

1.7 C ✓✓ (2)

1.8 D ✓✓ (2)

1.9 A ✓✓ (2)

1.10 D ✓✓ (2)
[20]

QUESTION/*VRAAG 2*

2.1 Compounds with one or more multiple bonds between C atoms in the hydrocarbon chain. ✓✓ (2 or 0)
Verbindings met een of meer meervoudige bindings tussen C-atome in die koolwaterstofkettings. (2 of 0)
OR/*OF*
A hydrocarbon with two or more bonds between the C-atoms.
'n Koolwaterstof met twee of meer bindings tussen die C-atome.
OR/*OF*
Hydrocarbons containing not only single bonds between C atoms.
Koolwaterstowwe wat nie slegs enkelbindings tussen die C-atome bevat nie.
ACCEPT/*AANVAAR:*
Compounds with one or more double/triple bonds between C atoms in the hydrocarbon chain.
Verbindings met een of meer dubbel/trippelbindings tussen C-atome in die koolwaterstofkettings. (2)

2.2.1 D ✓ (1)

2.2.2 2,4-dimethylhexane ✓✓✓
2,4-dimetielheksaan

Marking criteria:
- Correct stem i.e. hexane. ✓
- Substituents (dimethyl) correctly identified. ✓
- IUPAC name completely correct including numbering, sequence, hyphens and commas. ✓

Nasienkriteria:
- *Korrekte stam d.i. heksaan.* ✓
- *Substituente (dimetiel) korrek geïdentifiseer.* ✓
- *IUPAC-naam heeltemal korrek insluitende nommering, volgorde, koppeltekens en kommas.* ✓

(3)

2.2.3 Propan-2-ol /2-propanol ✓✓

Marking criteria:
- Correct stem i.e. propanol. ✓
- IUPAC name completely correct including numbering and hyphens. ✓

Nasienkriteria:
- *Korrekte stam d.i. propanol.* ✓
- *IUPAC-naam heeltemal korrek insluitende nommering en koppeltekens.* ✓

(2)

2.2.4 hept-1-ene/1-heptene ✓✓
hept-1-een/1-hepteen

Marking criteria:
- Correct stem i.e. heptene. ✓
- IUPAC name completely correct including numbering and hyphens. ✓

Nasienkriteria:
- *Korrekte stam d.i. hepteen.* ✓
- *IUPAC-naam heeltemal korrek insluitende nommering en koppeltekens.* ✓

(2)

2.2.5 **Marking criteria/*Nasienkriteria***
- Correct molecular formula: C_8H_{18} ✓
  Korrekte molekulêre formula: C_8H_{18}
- Correct molecular formula of inorganic reactant and products. ✓
  Korrekte molekulêre formule vir die anorganiese reaktant en produkte.
- Balancing/*Balansering* ✓

$2C_8H_{18}$ ✓ + $\underline{25O_2 \rightarrow 16CO_2 + 18H_2O}$ ✓ Bal ✓

Notes/*Aantekeninge:*
- Ignore double arrows and phases./*Ignoreer dubbelpyle en fases.*
- Marking rule 6.3.10/*Nasienreël 6.3.10.*
- If condensed structural formulae used:/*Indien gekondenseerde struktuurformules gebruik:* Max/*Maks.* $\frac{2}{3}$

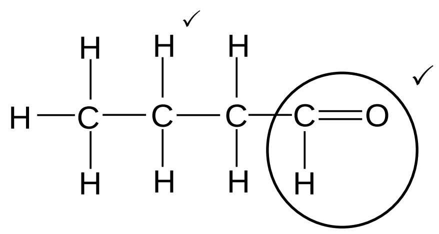
(3)

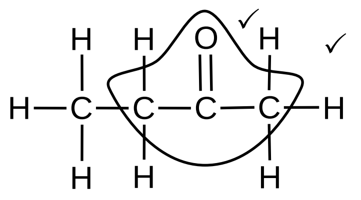
2.3.1 **Marking criteria/*Nasienkriteria***
If any one of the underlined key phrases in the correct context is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die korrekte konteks uitgelaat is, trek 1 punt af.*

Compounds with the <u>same molecular formula</u> but <u>different functional groups/homologous series</u>. ✓✓
Verbindings met <u>dieselfde molekulêre formule</u> maar <u>verskillende funksionele groepe/homoloë reekse</u>. (2)

2.3.2

Marking criteria/*Nasienkriteria*:	
• Functional group for aldehyde correct ✓ *Funksionele groep van aldehied korrek* • Whole structure of aldehyde correct ✓ *Hele struktuur van aldehied korrek*	• Functional group for ketone correct ✓ *Funksionele groep van ketoon korrek* • Whole structure of ketone correct ✓ *Hele struktuur van ketoon korrek*





(4)

2.4

Marking criteria

- Calculate the mass/percentage of oxygen. ✓
- Substitute correct mass and molar mass for both C and H into $n = \frac{m}{M}$. ✓
- Substitute correct mass and molar mass for O into $n = \frac{m}{M}$. ✓
- Simplify ratio. (Accept correct empirical formula if no ratio is given.) ✓
- Correct molecular formula. ✓✓

Nasienkriteria:

- *Bereken die massa/persentasie suurstof.* ✓
- *Vervang korrekte massa en molêre massa vir beide C en H in $n = \frac{m}{M}$.* ✓
- *Vervang korrekte massa en molêre massa vir O in $n = \frac{m}{M}$.* ✓
- *Vereenvoudig verhouding.* (Aanvaar korrekte empiriese formule indien geen verhouding nie) ✓
- *Korrekte molekulêre formule*. ✓✓

OPTION 1/*OPSIE 1*

	C	H	O
Mass / *Massa*	1,09	0,18	2 – (1,09 + 0,18) ✓ = 0,73
Moles /*mol*	$n = \frac{m}{M}$ $= \frac{1,09}{12}$ = 0,0908	$n = \frac{m}{M}$ $= \frac{0,18}{1}$ ✓ = 0,18	$n = \frac{m}{M}$ $= \frac{0,73}{16}$ ✓ = 0,046
Simplest ratio *Eenvoudigste verhouding*	2	4	1 ✓
Empirical formula *Empiriese formule*	C_2H_4O		

$M(C_2H_4O) \times n = 88\ (g{\cdot}mol^{-1})$

$44n = 88$

$n = 2$

Molecular formula of compound **X**/
Molekulêre formule van verbinding **X**: $C_4H_8O_2$ ✓✓

OPTION 2/*OPTION 2*

	C	H	O
Percentage/Persentasie	54,5	9	36,5 ✓
Moles /*mol*	$n = \frac{m}{M}$ $= \frac{54,5}{12}$ = 4,5417	$n = \frac{m}{M}$ $= \frac{9}{1}$ ✓ = 9	$n = \frac{m}{M}$ $= \frac{36,5}{16}$ ✓ = 2,28
Simplest ratio *Eenvoudigste verhouding*	2	4	1 ✓
Empirical formula *Empiriese formule*	C_2H_4O		

$M(C_2H_4O) \times n = 88\ (g\cdot mol^{-1})$
$44n = 88$
$n = 2$

Molecular formula of compound **X**/
Molekulêre formule van verbinding **X**: $C_4H_8O_2$ ✓✓ (6)

[25]

QUESTION/*VRAAG 3*

3.1

> **Marking criteria/*Nasienkriteria***
> If any one of the underlined key phrases in the correct context is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die korrekte konteks uitgelaat is, trek 1 punt af.*

The temperature at which the vapour pressure (of a compound) equals atmospheric pressure. ✓✓
Die temperatuur waarby die dampdruk (van 'n verbinding) gelyk is aan die atmosferiese druk. (2)

3.2

> **Marking criteria/*Nasienkriteria***
> - Compare compounds in terms of branches/chain lengths/surface area. ✓ *Vergelyk verbindings in terme van vertakkings/kettinglengte/oppervlakarea.*
> - Compare strengths of IMF's/*Vergelyk sterkte van IMK'e*.✓
> - Compare energy/*Vergelyk energie* ✓

Butan-1-ol ✓

- Has a longer chain length./is less branched./has a larger surface area/ contact area. ✓
- Strength of the intermolecular forces is greater./There are more sites for London forces. ✓
- More energy is needed to overcome/break intermolecular forces. ✓

- *Het 'n langer kettinglengte./is minder vertak./het 'n groter kontakoppervlak/reaksieoppervlak.* ✓
- *Sterkte van die intermolekulêre kragte verhoog./Daar is meer plekke vir Londonkragte.* ✓
- *Meer energie word benodig om die intermolekulêre kragte te oorkom/breek.* ✓

OR/*OF*

- 2-methylpropan-1-ol has a shorter chain length./is more branched./ has a smaller surface area/contact area.
- Strength of the intermolecular forces is weaker./There are fewer sites for London forces.
- Lesser energy is needed to overcome/break intermolecular forces.

- *2-metielpropan-1-ol het 'n korter kettinglengte./is meer vertak./het 'n kleiner kontakoppervlak/reaksieoppervlak.*
- *Sterkte van die intermolekulêre kragte is swakker./Daar is minder plekke vir Londonkragte.*
- *Minder energie word benodig om intermolekulêre kragte te oorkom/breek.* (4)

3.3 Boiling point/*Kookpunt* ✓ (1)

3.4

3.4.1 S ✓ (1)

3.4.2 P ✓ (1)

3.4.3 R ✓ (1)

3.5 Propanoic acid/P has the strongest intermolecular forces. ✓
OR
Two sites for hydrogen bonding (which is stronger than other intermolecular forces).
OR
Most energy needed to separate the chains.

Propanoësuur/P het die sterkste intermolekulêre kragte.
OF
Twee plekke vir waterstofbindings (wat sterker is as die ander intermolekulêre kragte).
OF
Meeste energie benodig om kettings te skei. (1)
[11]

QUESTION/*VRAAG 4*

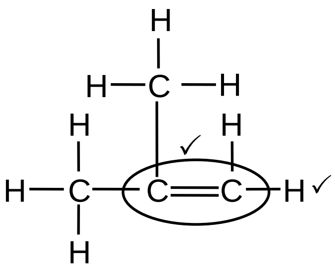
4.1

4.1.1 Halogenation/Bromination ✓
Halogenering/Brominering (1)

4.1.2 The bromine water/Br_2/solution <u>decolourises</u>./Brown <u>colour disappears</u>. ✓
Die broomwater/Br_2/oplossing <u>ontkleur</u>./Bruin <u>kleur verdwyn</u>.

OR/*OF*
Bromine water/Br_2/solution changes from <u>brown/reddish to colourless</u>.
Broomwater/Br_2/oplossing verander van <u>bruin/rooierig na kleurloos</u>. (1)

4.1.3



<u>Marking criteria/*Nasienkriteria*</u>
• Functional group correct ✓ *Funksionele groep korrek*
• Whole structure correct ✓ *Hele struktuur korrek*

(2)

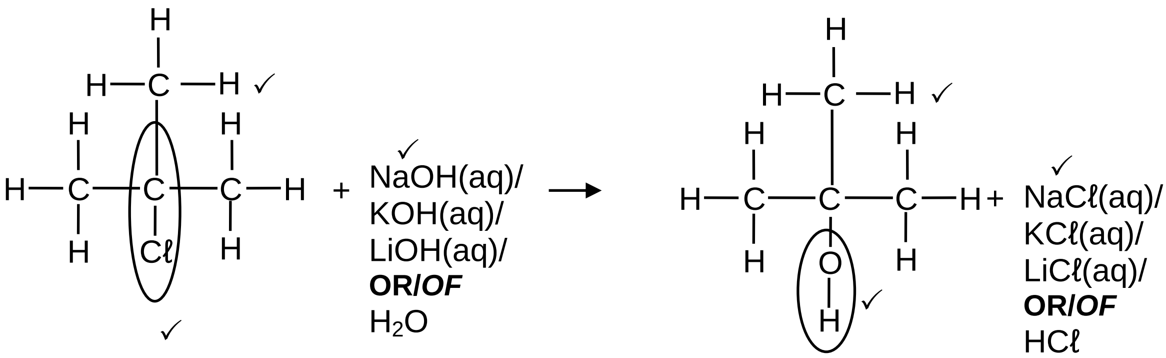
4.1.4 <u>2-chloro-2-methyl</u>✓<u>propane</u>✓ /*<u>2-chloro-2-metielpropaan</u>*

<u>ACCEPT/*AANVAAR*</u>*:*
2-chloromethylpropane / 2-*chlorometielpropaan* (2)

4.1.5

Marking criteria:
- Cℓ atom on second C atom on compound R ✓
- Whole structure of compound R correct ✓
- React compound R with NaOH(aq)/ KOH(aq)/LiOH(aq) **OR** H_2O ✓
- OH-group replaces Cℓ atom at the same position. ✓
- Whole structure of alcohol correct. ✓
- NaCℓ(aq)/KCℓ(aq)/LiCℓ(aq) **OR** HCℓ(aq) ✓
  (must correspond to the inorganic reactant used)

Nasienkriteria:
- *Cℓ-atoom op tweede C-atoom van verbinding R* ✓
- *Hele struktuur van verbinding R korrek* ✓
- *Reageer verbinding R met NaOH*(aq)/ *KOH*(aq)/*LiOH*(aq) ***OF*** *H_2O* ✓
- *OH-groep vervang Cℓ-atoom by dieselfde posisie.* ✓
- *Hele struktuur van alkohol korrek.* ✓
- *NaCℓ(aq)/KCℓ(aq)/LiCℓ(aq)* ***OF*** *HCℓ(aq)* ✓
  (moet ooreenstem met die anorganiese reaktans gebruik)



Notes/*Aantekeninge*:
- Ignore/*Ignoreer* ⇌
- Accept all inorganic reagents as condensed./*Aanvaar alle anorganiese reagense as gekondenseerd.*
- Accept coefficients that are multiples.
  Aanvaar koëffisiënte wat veelvoude is.
- Any additional reactants and/or products
  Enige addisionele reaktanse en/of produkte: Max./*Maks.* $^5/_6$
- Incorrect balancing/*Verkeerde balansering*: Max./*Maks.* $^5/_6$
- Molecular formulae/M*olekulêre formule*: Max./*Maks.* $^3/_6$
- Condensed formulae/G*ekondenseerde formule:* Max./*Maks.* $^4/_6$

Accept/*Aanvaar*:
-OH as condensed / *-OH as gekondenseerd*

Condensed formulae/G*ekondenseerde formule:*

$CH_3C(CH_3)CℓCH_3$ ✓ + ✓ NaOH(aq)/ KOH(aq)/ LiOH(aq)/ **OR/*OF*** H_2O ⟶ $CH_3C(CH_3)OHCH_3$ ✓ ✓ + NaCℓ(aq)/ KCℓ(aq)/ LiCℓ(aq)/ **OR/*OF*** HCℓ

(6)

4.1.6 2-methyl✓propan-2-ol✓/2-methyl-2-propanol
2-metielpropan-2-ol/2-metiel-2-propanol
ACCEPT/AANVAAR:
Methylpropan-2-ol/ *Metielpropan-2-ol* (2)

4.1.7 Dehydration/*Dehidrasie/Dehidratering* ✓ (1)

4.2.1 Esterfication/Condensation ✓
Verestering/Esterfikasie/Kondensasie (1)

4.2.2 Butyl✓propanoate ✓
Butielpropanoaat (2)
[18]

QUESTION/*VRAAG 5*

5.1 Initial concentration is 0 (of NO_2)./Concentration increases./
Curve starts at 0. ✓
Beginkonsentrasie is 0 (van NO_2)./Konsentrasie verhoog./Kurwe begin by 0.

OR/*OF*
Curve B has an initial concentration and is the reactant as its concentration decreases.
Kurwe B het 'n beginkonsentrasie en is die reaktant aangesien sy konsentrasie afneem. (1)

5.2 True/*Waar* ✓
n mol of N_2O_5 forms 2n mol of NO_2 per unit time. ✓
n mol N_2O_5 vorm 2n mol NO_2 per eenheidstyd.

OR/*OF*
Gradient of graph for NO_2 is twice the gradient of graph for N_2O_5.
Gradiënt van grafiek vir NO_2 is twee keer die gradiënt van grafiek vir N_2O_5.
NOTE/*LET WEL*:
If gradients calculated correctly award mark.
Indien gradiënte korrek bereken word punt toegeken. (2)

5.3.1

<u>Marking criteria/*Nasienkriteria:*</u>

- Formula: $c = \frac{m}{MV}$ / $n(NO_2) = cV$ / $n(NO_2) = \frac{m}{M}$ ✓
- Substitute change in concentration. ✓
  Vervang verandering in konsentrasie .
- Substitute M (46) and V (2)./*Vervang M (46) en V (2).* ✓
- Final correct answer/ *Finale korrekte antwoord:* 1,84 g ✓

<u>OPTION 1/*OPSIE 1*</u>

$c(NO_2) = \frac{m}{MV}$ ✓

200×10^{-4} ✓ $= \frac{m}{(46)(2)}$ ✓

$m = 1,84$ g ✓

<u>OPTION 2/*OPSIE 2*</u>

$n(NO_2) = cV$ ✓

$= (200 \times 10^{-4})$ ✓ $\times 2$

$= 4 \times 10^{-2}$ mol

✓ either/ *enige een*

$n(NO_2) = \frac{m}{M}$

$4 \times 10^{-2} = \frac{m}{46}$

✓ both/ *beide*

$m = 1,84$ g ✓

(4)

5.3.2

<u>Marking criteria/*Nasienkriteria:*</u>

- Substitute the change in concentration into rate formula. ✓
  Vervang verandering in konsentrasie in tempo formule.
- Substitute time into the rate formula./ *Vervang tyd in tempo formule.* ✓
- Use mol ratio/*Gebruik molverhouding:* rate/*tempo*(O_2) = ½ rate/*tempo*(N_2O_5)/ rate/*tempo*(O_2) = ¼ rate/*tempo*(NO_2) ✓
- Final correct answer/*Finale korrekte antwoord:* 1×10^{-5} ($mol \cdot dm^{-3} \cdot s^{-1}$) ✓

NOTE/LET WEL

If concentration is converted to moles, final moles per s ($mol \cdot s^{-1}$) must be converted back to concentration ($mol \cdot dm^{-3} \cdot s^{-1}$). i.e. there must be multiplication and division by 2. If one of these is omitted: Max. $^{2}/_{4}$

Indien konsentrasie omgeskakel is na mol, moet die finale mol per s ($mol \cdot s^{-1}$) omgeskakel word na konsentrasie ($mol \cdot dm^{-3} \cdot s^{-1}$) d.w.s daar moet vermenigvuldig en gedeel word deur 2. Indien een van hierdie uitgelaat word: Maks. $^{2}/_{4}$

<u>OPTION 1/*OPSIE 1*</u>

Ave rate/*gem tempo* $= -\frac{\Delta c(N_2O_5)}{\Delta t}$

$= -\frac{(60 \times 10^{-4} - 200 \times 10^{-4})}{700\ (-0)}$ ✓ ✓

$= 2 \times 10^{-5}$ ($mol \cdot dm^{-3} \cdot s^{-1}$)

rate(O_2) = ½ rate(N_2O_5) = ½(2×10^{-5}) ✓

$= 1 \times 10^{-5}$ ($mol \cdot dm^{-3} \cdot s^{-1}$) ✓

<u>OPTION 2/*OPSIE 2*</u>

Ave rate/*gem tempo* $= \frac{\Delta c(NO_2)}{\Delta t}$

$= \frac{(280 \times 10^{-4}\ (-0))}{700\ (-0)}$ ✓ ✓

$= 4 \times 10^{-5}$ ($mol \cdot dm^{-3} \cdot s^{-1}$)

rate(O_2) = ¼ rate(NO_2) = ¼(4×10^{-5}) ✓

$= 1 \times 10^{-5}$ ($mol \cdot dm^{-3} \cdot s^{-1}$) ✓

OPTION 3/*OPSIE 3*

$\Delta c(O_2) = \frac{1}{2}\Delta c(N_2O_5)$
$= \frac{1}{2}(60 \times 10^{-4} - 200 \times 10^{-4})$ ✓
$= \frac{1}{2}(140 \times 10^{-4})$
$= 7 \times 10^{-3}\ mol\cdot dm^{-3}$

OR/*OF*

$\Delta c(O_2) = \frac{1}{4}\Delta c(NO_2)$
$= \frac{1}{4}(280 \times 10^{-4}$ ✓$(-0))$
$= 7 \times 10^{-3}\ mol\cdot dm^{-3}$
$= 7 \times 10^{-3}\ mol\cdot dm^{-3}$

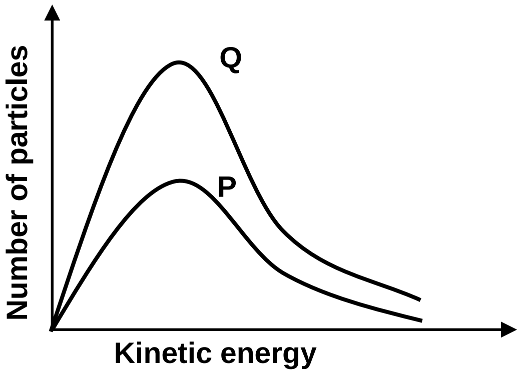
Ave rate/*gem tempo* $= \frac{\Delta c(O_2)}{\Delta t}$

$= \frac{(7 \times 10^{-3})\ ✓}{700\ (-0)\ ✓}$

$= 1 \times 10^{-5}\ (mol\cdot dm^{-3}\cdot s^{-1})$ ✓ (4)

5.4

5.4.1



Marking criteria/*Nasienkriteria*

- Curve Q must be above the given curve P and have the same shape as the given curve P and the peaks have to correspond. ✓
  Kurwe Q moet bo die gegewe kurwe P wees en moet dieselfde vorm hê as die gegewe kurwe P en die maksimums moet ooreenstem
- Starts at origin and not crossing curve P. ✓
  Begin by oorsprong en nie kruis met kurwe P nie.

(2)

5.4.2 Higher than/*Hoër as* ✓

- When the concentration of N_2O_5 is higher there are <u>more N_2O_5 particles per unit volume</u>. ✓
- <u>More effective collisions per unit time</u>/second. ✓
  OR
  Higher frequency of effective collisions.

- *'n Hoër konsentrasie van* N_2O_5 *bevat meer* N_2O_5*-deeltjies per eenheidsvolume.* ✓
- *Meer effektiewe botsings per eenheidstyd/sekonde.* ✓
  OF
  Hoër frekwensie van effektiewe botsings.

(3)
[16]

QUESTION/*VRAAG 6*

6.1

<u>Marking criteria/*Nasienkriteria:*</u>
If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

<u>When the equilibrium in a closed system is disturbed</u>, the system will <u>re-instate a (new) equilibrium</u> by <u>favouring the reaction</u> that will <u>cancel/oppose the disturbance.</u> ✓✓
<u>Wanneer die ewewig in 'n geslote sisteem versteur word</u>, sal die sisteem 'n (nuwe) <u>ewewig instel</u> deur <u>die reaksie te bevoordeel</u> wat die <u>versteuring kanselleer/teenwerk</u>. (2)

6.2
6.2.1 $n[H_2(g)] = 0{,}11$ (mol) ✓ (1)

6.2.2

<u>OPTION 1/*OPSIE 1*</u>	**<u>OPTION 2/*OPSIE 2*</u>**
$n(HI)_{used/gebruik} = 2n(I_2)$ $= 2(0{,}11)$ $n(HI)_{eq} = 1 - 0{,}22$ $= 0{,}78$ (mol) ✓	$K_c = \frac{[H_2][I_2]}{[HI]^2}$ $0{,}02 = \frac{(0{,}11)(0{,}11)}{[HI]^2}$ $[HI] = 0{,}78\ mol\cdot dm^{-3}$ $n(HI) = 0{,}78$ (mol) ✓

(1)

6.3
6.3.1 Endothermic/*Endotermies* ✓ (1)

6.3.2 K_c increased:

- The concentration of the product/$H_2(g)$ and $I_2(g)$ is increased. ✓
  OR: The concentration of the reactant/HI decreases.
- The increase in temperature favoures the forward reaction. ✓
- (According to Le Chatelier's principle) an increase in temperature favours the endothermic reaction. ✓

K_c het verhoog:

- *Die konsentrasie van die produkte/$H_2(g)$ en $I_2(g)$* verhoog. ✓
  OF: Die *konsentrasie van die reaktanse/HI verlaag.*
- *'n Toename in temperatuur bevoordeel die voorwaartse reaksie.* ✓
- *(Volgens Le Chatelier se beginsel) sal 'n toename in temperatuur die endotermiese reaksie bevoordeel.* ✓ (3)

6.3.3

<table>
<tr><th colspan="2">POSITIVE MARKING FROM Q6.2/POSITIEWE NASIEN VANAF V6.2</th></tr>
<tr><td>Marking criteria:
(a) Correct K_c expression (formulae in square brackets). ✓
(b) Substitution of 0,09 in Kc expression. ✓
(c) Correct initial moles from 6.2.1 and 6.2.2. ✓
(d) USING ratio: $nHI(g) : 2nI_2(g) = 1:2$ ✓
(e) Substitution of concentrations into correct K_c expression. ✓
(f) Subtraction $[HI]_{ini} - \Delta[HI]$ ✓
(g) Substitution of 128 in m = nM. ✓
(h) Final answer: 80,64 g ✓
(range: 79,36 - 80,64 g)</td>
<td>Nasienkriteria:
(a) Korrekte K_c uitdrukking (formules in vierkantige hakies). ✓
(b) Vervang 0,09 in Kc uitdrukking. ✓
(c) Aanvanklike mol korrek vanaf 6.2.1 en 6.2.2. ✓
(d) GEBRUIK verhouding: $nHI(g) : 2nI_2(g) = 1:2$ ✓
(e) Vervang konsentrasies in korrekte K_c uitdrukking. ✓
(f) Verskil: $[HI]_{aanv} - \Delta[HI]$ ✓
(g) Vervang 128 in m = nM. ✓
(h) Finale antwoord: 80,64 g ✓
(gebied: 79,36 - 80,64 g)</td></tr>
</table>

OPTION 1/*OPSIE 1*

$$K_c = \frac{[H_2][I_2]}{[HI]^2} \checkmark \textbf{(a)}$$

✓ **(c)** (0,11 and/*en* 0,78 from 6.2.1 and/*en* 6.2.2)

(b) ✓

$$0{,}09 = \frac{(0{,}11 + x)(0{,}11 + x)}{(0{,}78 - 2x)^2} \checkmark \textbf{(e)} \checkmark \textbf{(d)}$$

x = 0,0775

$[HI]_{\text{equilibrium/}\textit{ewewig}} = [HI]_{\text{ini/aanv}} - \Delta[HI]$
= $\underline{0{,}78 - 2(0{,}0775)}$ ✓**(f)**
= 0,63 $mol{\cdot}dm^{-3}$ (0,625)

n(HI) = cV
= (0,63)(1)
= 0,63 mol (0,625)

m(HI) = nM
= (0,63)(128) ✓ **(g)**
= 80,64 g ✓ **(h)**

OR/*OF*
m(HI) = cVM
= (0,63)(1)(128) ✓ **(g)**
= 80,64 g ✓ **(h)**

OPTION 2/*OPSIE 2*

	HI	I_2	H_2
Initial quantity (mol) *Aanvanklike hoeveelheid (mol)*	0,78	0,11	0,11
Change (mol) *Verandering (mol)*	2x	x	x
Quantity at equilibrium (mol) *Hoeveelheid by ewewig (mol)*	0,78 - 2x	0,11 + x	0,11 + x
Equilibrium concentration *Ewewigskonsentrasie* ($mol\cdot dm^{-3}$)	$\frac{0,78-2x}{1}$	$\frac{0,11+x}{1}$	$\frac{0,11+x}{1}$

Ratio 1:2 ✓

$K_c = \frac{[H_2][I_2]}{[HI]^2}$ ✓**(a)**

(b)

$0,09 = \frac{(0,11 + x)(0,11 + x)}{(0,78 - 2x)^2}$ ✓ ✓**(e)**

x = 0,0775

(f)

$[HI]_{\text{equilibrium/}\textit{ewewig}} = \underline{0,78 - 2(0,0775)}$ ✓

$= 0,63\ mol\cdot dm^{-3}$ (0,625)

n(HI) = cV
= (0,63)(1)
= 0,63 mol (0,625 mol)

m(HI) = nM
= (0,63)(128) ✓**(g)**
= 80,64 g ✓**(h)**

OR/*OF*
m(HI) = cVM
= (0,63)(1)(128) ✓ **(g)**
= 80,64 g ✓ **(h)**

(8)
[16]

QUESTION/*VRAAG 7*

7.1
7.1.1 **ANY ONE***:*

- A substance whose aqueous solution contains ions. ✓✓ **(2 or 0)**
- Substance that dissolves in water to give a solution that conducts electricity.
- A substance that forms ions in water/forms ions when molten.

ENIGE EEN:

- *'n Stof waarvan die oplossing ione bevat.* ✓✓ ***(2 of 0)***
- *'n Stof wat in water oplos om 'n oplossing te vorm wat elektrisiteit gelei.*
- *'n Stof wat ione vorm in water/ione vorm wanneer gesmelt.* (2)

7.1.2 A ✓

H_2SO_4 is diprotic./Donates more than one mole of H^+ ions per mole of acid ✓ (and both acids are of the same concentration)./H_2SO_4 has a higher K_a value.
H_2SO_4 is diproties./Skenk meer as een mol H^+ ione per mol suur (en beide sure het dieselfde konsentrasie)/ H_2SO_4 het 'n hoër K_a-waarde.

OR/*OF*

It ionises to produce more than one mole of protons/H^+ ions for each mole of H_2SO_4./H_2SO_4 has a higher K_a value.
Dit ioniseer om meer as een mol protone/ H^+-ione vir elke mol H_2SO_4 te vorm./H_2SO_4 het 'n hoër K_a-waarde. (2)

7.1.3 B ✓

Stronger acid/ionises completely ✓(and both acids are of the same concentration)./HNO_3 has a higher K_a value.
Sterker suur/ioniseer volledig (en beide sure het dieselfde konsentrasie)./ HNO_3 het 'n hoër K_a-waarde.

OR/*OF*

C/CH_3COOH is a weaker acid/ionises incompletely.
C/CH_3COOH is 'n swak suur/ioniseer onvolledig. (2)

7.2

7.2.1

<u>Marking criteria/*Nasienkriteria:*</u>

- Substitute/*Vervang* 0,04 mol·dm^{-3} and 25 x 10^{-3} dm^3 (25 cm^3) and 19,5 x 10^{-3} dm^3 (19,5 cm^3). ✓
- USE mol ratio:/*GEBRUIK molverhouding:* n(Na_2CO_3) : n(HCℓ) = 1 : 2 ✓
- Final answer/*Finale antwoord:* 0,10 to/*tot* 0,103 mol·dm^{-3} ✓

<u>OPTION 1/*OPSIE 1*</u>	**<u>OPTION 2/*OPSIE 2*</u>**
$\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$ $\frac{c_a(19,5)}{(0,04)(25)}$ ✓ $= \frac{2}{1}$ ✓ c_a = 0,10 mol·dm^{-3} ✓ (0,103)	n(Na_2CO_3) = cV = <u>0,04 x 0,025</u> = 0,001 mol n(HCℓ) = 2n(Na_2CO_3) = 0,002 mol ✓ [HCℓ] = $\frac{n}{V}$ $= \frac{0,002}{0,0195}$ ✓ = 0,10 mol·dm^{-3} ✓ (0,103)

(3)

7.2.2 Greater than/*Groter as* ✓

The few drops of water will <u>dilute the HCℓ</u>, ✓therefore greater volume of acid will be needed to neutralise the base.
'n Paar druppels water sal die <u>HCℓ verdun</u>, daarom sal 'n groter volume suur benodig word om die basis te neutraliseer. (2)

7.2.3

POSITIVE MARKING FROM Q7.2.1/*POSITIEWE NASIEN VANAF V7.2.1*

Marking criteria:	***Nasienkriteria:***
(a) Substitute 0,1 mol·dm^{-3} & 18,7 x 10^{-3} dm^3 (18,7 cm^3). ✓ (b) Use mole ratio: 1:1 ✓ (c) Calculate $n(NH_3)$ / $m(NH_3)$ in 250 cm^3: Substitute 0,25 dm^3 (250 cm^3) ✓ (d) Substitute 0,022 dm^3 (22 cm^3). ✓ (e) Substitute 0,02 dm^3 (20 cm^3) to calculate mole/mass in initial solution. ✓ (f) Use 17 g·mol^{-1} in $n = \frac{m}{M}$. ✓ (g) Final answer: 18,06 g ✓ Range: 17 to 19,13 g	(a) *Vervang 0,1 mol·dm^{-3} & 18,7 x 10^{-3} dm^3 (18,7 cm^3).* ✓ (b) *Gebruik molverhouding: 1:1* ✓ (c) *Bereken $n(NH_3)$ / $m(NH_3)$ in 250 cm^3: Vervang 0,25 dm^3 (250 cm^3).* ✓ (d) *Vervang 0,022 dm^3 (22 cm^3).* ✓ (e) *Vervang 0,02 dm^3 (20 cm^3) om mol/massa van oorspronklike oplossing te bereken.* ✓ (f) *Gebruik 17 g·mol^{-1} in* $n = \frac{m}{M}$. ✓ (g) *Finale antwoord:* 18,06 g ✓ *Gebied*: 17 *tot* 19,13 g
OPTION 1/*OPSIE 1* $n(HC\ell) = cV$ $= \underline{(0,1)(18,7 \times 10^{-3})}$ ✓ **(a)** $= 1,87 \times 10^{-3}$ mol $n(NH_3)_{reacted/reageer} = n(HC\ell)_{reacted/reageer}$ $= 1,87 \times 10^{-3}$ mol ✓**(b)** $n(NH_3)$ in 22 cm^3 = $1,87 \times 10^{-3}$ mol $n(NH_3)$ in 250 cm^3 = $\frac{(1,87 \times 10^{-3})(250)}{22}$ ✓**(c)** ✓**(d)** = 0,021 mol ($2,13 \times 10^{-2}$) $n(NH_3)$ in initial 20 cm^3 = 0,021 mol $n = \frac{m}{M}$ $0,021 = \frac{m}{17}$ ✓ **(f)** $m(NH_3)$ = 0,357 g in 20 cm^3 $m(NH_3) = \frac{(0,357)(1000)}{20}$ ✓**(e)** = 17,85 g✓**(g)** (18,06)	**OPTION 2/*OPSIE 2*** $n(HC\ell) = cV$ $= \underline{(0,1)(18,7 \times 10^{-3})}$ ✓**(a)** $= 1,87 \times 10^{-3}$ mol $(NH_3)_{reacted/reageer} = n(HC\ell)_{reacted/reageer}$ $= 1,87 \times 10^{-3}$ mol ✓**(b)** $n(NH_3)$ in 22 cm^3 = $1,87 \times 10^{-3}$ mol $n = \frac{m}{M}$ $1,87 \times 10^{-3} = \frac{m}{17}$ ✓ **(f)** $m(NH_3)$ = $3,72 \times 10^{-3}$ g in 22 cm^3 $m(NH_3)$ in 250 cm^3 = $\frac{(3,72 \times 10^{-3})(250)}{22}$ ✓**(c)** ✓**(d)** = 0,361 g $m(NH_3)$ in initial 20 cm^3 = 0,361 g $m(NH_3)$ in 1 000 cm^3 = $\frac{(0,361)(1000)}{20}$ ✓**(e)** = 18,06 g✓**(g)**

(7)

<u>OPTION 3/*OPSIE 3*</u>

$$\frac{c_bV_b}{c_aV_a} = \frac{n_b}{n_a}$$

$$\frac{c_b(22)\ ✓\textbf{(d)}}{(0,1)(18,7)\ ✓\textbf{(a)}} = \frac{1}{1}\ ✓\ \textbf{(b)}$$

$c_1 = 0,085\ mol\cdot dm^{-3}$

$[NH_3]$ in 22 cm^3 = $0,085\ mol\cdot dm^{-3}$

$[NH_3]$ in 250 cm^3 = $0,085\ mol\cdot dm^{-3}$

$c_1V_1 = c_2V_2$

$c_1(0,02)$ ✓ **(e)** = $\underline{(0,085)(0,25)}$ ✓ **(c)**

$c_1 = 1,06\ mol\cdot dm^{-3}$

m = cVM **(f)**

= (1,06)(1)(17✓)

= 18,06 g ✓ **(g)**

<u>OPTION 4/*OPSIE 4*</u>

n(HCℓ)= cV

= $\underline{(0,1)(18,7 \times 10^{-3})}$ ✓ **(a)**

= $1,87 \times 10^{-3}$ mol

$(NH_3)_{reacted/reageer}$ = $n(HCℓ)_{reacted/reageer}$

= $1,87 \times 10^{-3}$ mol ✓**(b)**

$n(NH_3)$ in 22 cm^3 = $1,87 \times 10^{-3}$ mol

✓ **(c)**

$n(NH_3)$ in 250 cm^3 = $\frac{(1,87 \times 10^{-3})(250)}{22}$ ✓**(d)**

= 0,021 mol

$c(20\ cm^3) = c(1\ dm^3)$

$\frac{n_1}{V_1} = \frac{n_2}{V_2}$

$n(NH_3)$ in 1 000 cm^3 = $\frac{0,021 \times 1000}{20}$ ✓ **(e)**

= 1,06 mol

$n = \frac{m}{M}$

$1,06 = \frac{m}{17}$ ✓**(f)**

$m(NH_3)$ = 18,06 g ✓**(g)**

7.2.4 Less than 7/*Minder as 7* ✓

$NH_4^+(aq) + H_2O(ℓ)$ ✓ $\rightleftharpoons NH_3(aq) + H_3O^+(aq)$ ✓

<u>Notes/*Aantekeninge*:</u>

- Ignore single arrow/*Ignoreer* enkelpyl: →

(3)

[21]

QUESTION/*VRAAG 8*

8.1
- Pressure: <u>1 atmosphere</u> /101,3 kPa /1,01 x 10^5 Pa ✓
  Druk: <u>1 atmosfeer</u> /101,3 kPa /1,01 x 10^5 Pa
- Temperature/*Temperatuur*: <u>25 °C</u> /298 K ✓
- Concentration of electrolytes: <u>1 mol·dm^{-3}</u> ✓
  Konsentrasie van elektroliete: <u>1 mol·dm^{-3}</u>

(3)

8.2 To maintain electrical neutrality/To complete the circuit/To allow movement of ions between electrolytes ✓
Om elektriese neutraliteit te verseker/Om die stroombaan te voltooi/Laat ione toe om tussen elektroliete te beweeg (1)

8.3

<table>
<tr>
<td>

OPTION 1/*OPTION 1*

$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ ✓

$1{,}20$ ✓ $= E^{\theta}_{cathode} - 0$ ✓

$E^{\theta}_{cathode} = 1{,}20$ (V) ✓

X is Pt/platinum ✓

</td>
<td>

Notes/*Aantekeninge*

- Accept any other correct formula from the data sheet./*Aanvaar enige ander korrekte formule vanaf gegewensblad.*
- Any other formula using unconventional abbreviations, e.g. $E°_{cell} = E°_{OA} - E°_{RA}$ followed by correct substitutions:/*Enige ander formule wat onkonvensionele afkortings gebruik, bv.* $E°_{sel} = E°_{OM} - E°_{RM}$ *gevolg deur korrekte vervangings:* Max./*Maks.* $\frac{4}{5}$

</td>
</tr>
<tr>
<td colspan="2">

OPTION 2/*OPSIE 2*

✓ $X^{2+} + 2e^- \rightarrow X$ $E^{\theta} = 1{,}20$ V ✓

$H_2 \rightarrow 2H^+ + 2e^-$ $E^{\theta} = 0{,}00$ V ✓

$H_2 + X^{2+} \rightarrow X + 2H^+$ $E^{\theta} = 1{,}20$ V ✓

X is Pt/Platinum ✓

</td>
</tr>
</table>

(5)

8.4 $H_2(g) \rightarrow 2H^+(aq) + 2e^-$ ✓✓

<table>
<tr>
<td>

Marking criteria/*Nasienkriteria:*

- $2H^+(aq) + 2e^- \leftarrow H_2(g)$ ($\frac{2}{2}$) $H_2(g) \rightleftharpoons 2H^+(aq) + 2e^-$ ($\frac{1}{2}$)
  $H_2(g) \leftarrow 2H^+(aq) + 2e^-$ ($\frac{0}{2}$) $2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$ ($\frac{0}{2}$)
- Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.*
- If charge (+) omitted on H^+/*Indien lading (+) weggelaat op* H^+:
  Example/*Voorbeeld:* $H_2(g) \rightarrow 2H(aq) + 2e^-$ Max./*Maks.* $\frac{1}{2}$

</td>
</tr>
</table>

(2)

8.5 H^+, X^{2+} (Pt^{2+}), Au^{3+}✓

- H_2 loses/donates electrons to both Au and X/Pt. ✓
  OR
  H_2 is the anode/is oxidised in both cells.
  Therefore H^+ is the weakest oxidising agent.

- The reduction potential of X│X^{2+} is 1,2 V and that of Au│Au^{3+} is 1,5 V. ✓
  OR
  The reduction potential of X│X^{2+} is smaller than that of Au│Au^{3+}.
  OR
  According to the Table of Standard Reduction Potentials Au^{3+} is stronger oxidation agent than Pt^{2+}.
  OR
  The cell containing Au produces a higher emf than cell containing X.

- *H_2 verloor/skenk elektrone aan beide Au en X/Pt*. ✓
  OF
  H_2 is die anode/word geoksideer in beide selle.
  Daarom is H^+ die swakste oksideermiddel

- *Die reduksiepotensiaal van X│X^{2+} is 1,2 V en die van Au│Au^{3+} is 1,5 V.* ✓
  OF
  Die reduksiepotensiaal van X│X^{2+} is kleiner as dié van Au│Au^{3+}.
  OF
  Volgens *die Tabel van Standaardreduksiepotensiale is Au^{3+} 'n sterker oksideermiddel as* Pt^{2+}
  OF
  Die sel wat Au bevat het 'n hoër emk as die sel wat X bevat. (3)

[14]

QUESTION/*VRAAG 9*

9.1 A cell in which electrical energy is converted into chemical energy. ✓✓ (2 or 0)
'n Sel waar elektriese energie na chemiese energie omgeskakel word. (2 of 0) (2)

9.2 R ✓
Oxidation takes place./R loses electrons./R decreases in mass. ✓
Oksidasie vind plaas./R verloor elektrone./R se massa sal afneem. (2)

9.3

9.3.1 $Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$ ✓✓
Ignore phases/*Ignoreer fases*

Marking criteria/*Nasienkriteria:*

- $Zn(s) \leftarrow Zn^{2+}(aq) + 2e^-$ $(\frac{2}{2})$ $Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$ $(\frac{1}{2})$
  $Zn^{2+}(aq) + 2e^- \leftarrow Zn(s)$ $(\frac{0}{2})$ $Zn(s) \rightleftharpoons Zn^{2+}(aq) + 2e^-$ $(\frac{0}{2})$
- Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.*
- If charge (+) omitted on Zn^{2+}/*Indien lading (+) weggelaat op* Zn^{2+}:
  Example/*Voorbeeld:* $Zn^{2}(aq) + 2e^- \rightarrow Zn(s)$ Max./*Maks:* $\frac{1}{2}$

(2)

9.3.2 Zinc/Zn/*Sink* ✓ (1)

9.4 <u>Zn^{2+} ions are reduced/[Zn^{2+}] decreases.</u> ✓
Zn^{2+} ions must be replaced by oxidation of the Zn electrode. ✓
<u>Zn^{2+} ione word gereduseer/[Zn^{2+}] neem af.</u>
Zn^{2+} ione moet vervang word deur oksidasie van Zn-elektrode. (2)
[9]

TOTAL/*TOTAAL:* **150**