basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL
SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

NOVEMBER 2024

MARKS: 150

TIME: 3 hours

This question paper consists of 17 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. Show ALL formulae and substitutions in ALL calculations.

8. Round off your FINAL numerical answers to a minimum of TWO decimal places.

9. Give brief motivations, discussions, etc. where required.

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

11. 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 Which ONE of the following compounds has hydrogen bonds between its molecules?

A CH_3CH_2CHO

B CH_3COOCH_3

C $CH_3CH_2CH_2OH$

D CH_3COCH_3 (2)

1.2 Which ONE of the following is a CORRECT GENERAL FORMULA for the carboxylic acids?

A $C_nH_{2n+1}O_2$

B $C_nH_{2n}O_{2n}$

C $C_nH_{2n}O_2$

D $C_nH_nO_2$ (2)

1.3 Study the reactions below.

Reaction **1**: $CH_3CH_2CHOHCH_3 \xrightarrow[\text{conc.}]{H_2SO_4}$ Compound **P** (major product) + H_2O

Reaction **2**: Compound **P** $\xrightarrow{\text{hydrogenation}}$ Compound **Q**

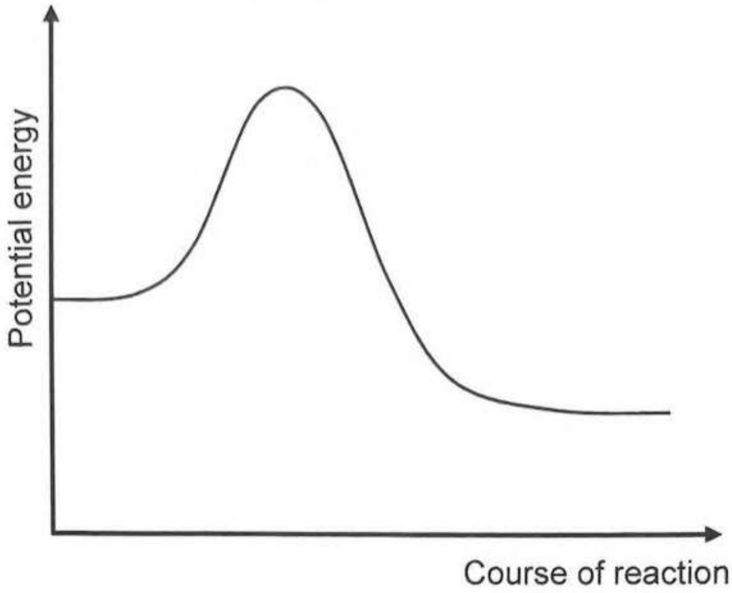
Which ONE of the following combinations is the CORRECT IUPAC names of compounds **P** and **Q**?

	COMPOUND P	COMPOUND Q
A	But-1-ene	Butane
B	But-2-ene	Butane
C	But-1-ene	Butan-2-ol
D	But-2-ene	Butan-2-ol

(2)

1.4 The potential energy diagram below is for the following hypothetical chemical reaction:

$$X + Y \rightleftharpoons Z$$



Which ONE of the following combinations of values for the heat of the reaction and the activation energies can be obtained for this reaction?

	$\Delta H_{(forward)}$ ($kJ \cdot mol^{-1}$)	$E_{A(forward)}$ ($kJ \cdot mol^{-1}$)	$E_{A(reverse)}$ ($kJ \cdot mol^{-1}$)
A	-400	300	100
B	-200	300	100
C	+400	100	300
D	-200	100	300

(2)

1.5 Initially, an equal number of moles of hydrogen gas, $H_2(g)$, and iodine gas, $I_2(g)$, are mixed in a closed container. The reaction reaches equilibrium at a constant temperature according to the balanced equation.

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

Which ONE of the following is ALWAYS TRUE at equilibrium?

A $[H_2] = [I_2]$

B $[HI] = [I_2]$

C $[HI] = 2[H_2]$

D $[H_2] = [I_2] = [HI]$ (2)

1.6 Consider the following reaction at equilibrium:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -188\ kJ\cdot mol^{-1}$$

Which ONE of the changes to the reaction conditions below will increase the yield of $SO_3(g)$?

A The addition of $O_2(g)$

B The addition of a catalyst

C An increase in temperature

D An increase in the volume of the container at a constant temperature (2)

1.7 The table below shows the ionisation constants, K_a, for two acids at 25 °C.

ACID	K_a
Butanoic acid	$1,5 \times 10^{-5}$
Ethanoic acid	$1,8 \times 10^{-5}$

Consider the following statements for these two acids when they have equal concentration at 25 °C:

(i) Both are weak acids.
(ii) Butanoic acid is a stronger acid than ethanoic acid.
(iii) The butanoic acid solution has a lower concentration of hydronium ion, $H_3O^+(aq)$, than the ethanoic acid solution.

Which of the above statements are TRUE?

A (i) and (ii) only

B (i) and (iii) only

C (ii) and (iii) only

D (i), (ii) and (iii) (2)

1.8 Which ONE of the following pairs of acids and bases, all of the same concentration, react to give the highest pH at the equivalence point in a titration at 25 °C?

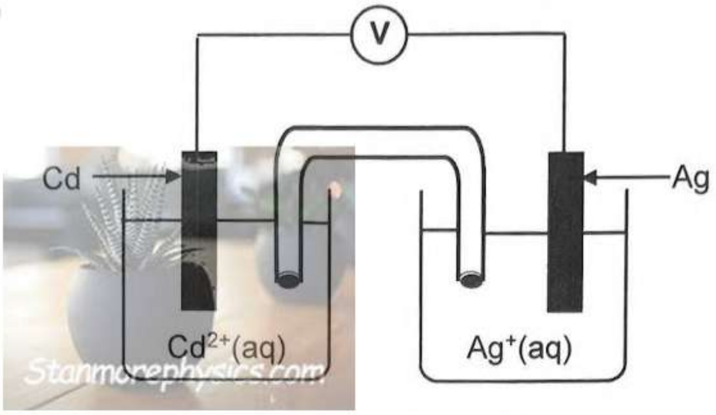
A $HC\ell$ and NH_3

B $HC\ell$ and $NaOH$

C HNO_3 and KOH

D CH_3COOH and $NaOH$ (2)

1.9 A standard galvanic cell is set up, as shown below.

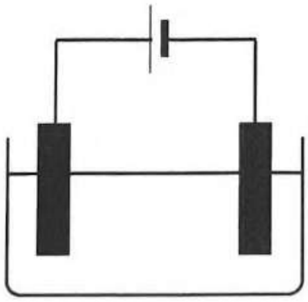


Which ONE of the following combinations of the metal used as cathode and the electron flow direction is CORRECT?

	METAL USED AS CATHODE	ELECTRON FLOW DIRECTION
A	Cd	Cd to Ag
B	Ag	Cd to Ag
C	Cd	Ag to Cd
D	Ag	Ag to Cd

(2)

1.10 An electrolytic cell is set up to electroplate an iron rod with nickel, as shown in the diagram below.



Consider the following statements:

(i) The iron rod is the negative electrode.
(ii) The metal ions in the solution undergo reduction.
(iii) The anode is pure nickel.

Which of the above statements are TRUE?

A (i) and (ii) only

B (i) and (iii) only

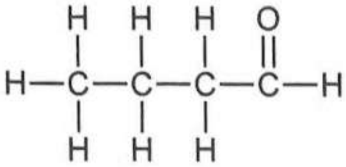
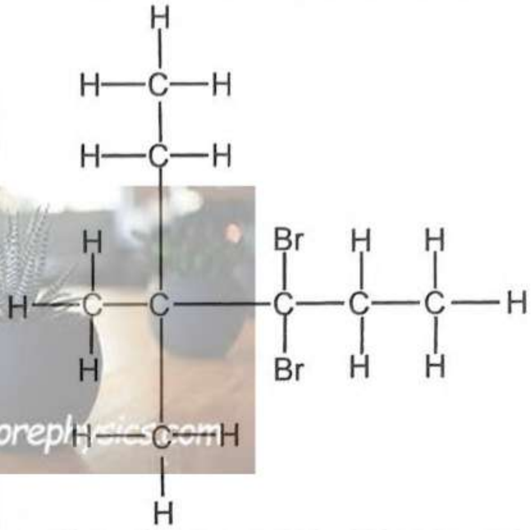
C (ii) and (iii) only

D (i), (ii) and (iii)

(2)
[20]

QUESTION 2 (Start on a new page.)

The letters **A** to **H** in the table below represent organic compounds.

A		**B**	
C	Butanone	**D**	$C_4H_{10}O$
E	$CH_3C(CH_3)_2CCCH_3$	**F**	$CH_3COO(CH_2)_2CH_3$
G	$C_4H_8O_2$	**H**	$CH_3C(CH_3)_2CH_2CH_3$

2.1 Write down the LETTER that represents EACH of the following:

2.1.1 An alcohol (1)

2.1.2 A compound with a formyl group (1)

2.1.3 An unsaturated compound (1)

2.2 Write down the IUPAC name of compound:

2.2.1 **B** (3)

2.2.2 **E** (3)

2.3 Two different compounds in the above table are functional isomers.

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

2.3.2 Write down the LETTERS that represent these functional isomers. (1)

2.4 Compound **F** is formed when a carboxylic acid reacts with another organic compound, **X**, in the presence of a catalyst.

Write down the:

2.4.1 NAME or FORMULA of the catalyst (1)

2.4.2 Type of reaction (1)

2.4.3 STRUCTURAL FORMULA of compound **F** (2)

2.4.4 IUPAC name of compound **X** (2)
[18]

QUESTION 3 (Start on a new page.)

The vapour pressures of different organic compounds are determined at 20 °C. The vapour pressures of compounds **A**, **B** and **C** are NOT shown in the table.

COMPOUND	IUPAC NAME	MOLAR MASS ($g \cdot mol^{-1}$)	VAPOUR PRESSURE (kPa) AT 20 °C
A	Pentane	72	
B	2-methylbutane	72	
C	2,2-dimethylpropane	72	
D	Propanoic acid	74	0,32
E	Butanal	72	12,2

3.1 Define the term *vapour pressure.* (2)

3.2 The vapour pressures of compounds **A**, **B** and **C** are given in random order below.

79 kPa	146 kPa	58 kPa

3.2.1 Write down the vapour pressure of compound **C**. (1)

3.2.2 Fully explain your answer to QUESTION 3.2.1. (3)

3.3 Compounds **D** and **E** are compared.

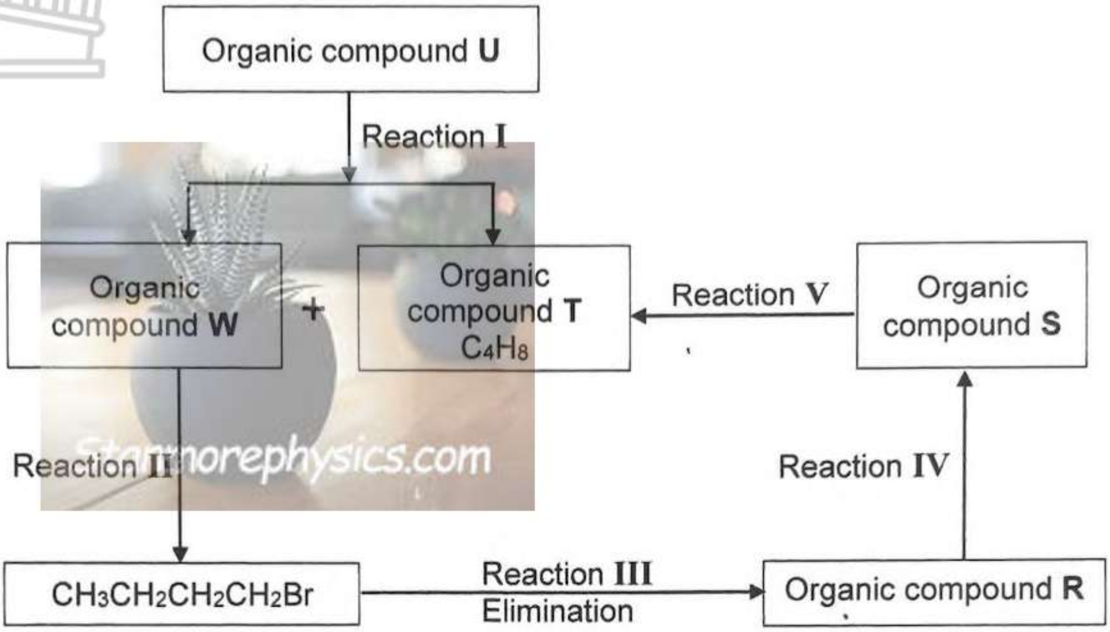
3.3.1 Which compound has the lower boiling point? (1)

3.3.2 Fully explain the difference in the vapour pressures between compounds **D** and **E**. (4)
[11]

QUESTION 4 (Start on a new page.)

Study the flow diagram below.

Reaction **I** is a CRACKING REACTION forming two organic compounds, **W** and **T**, as the ONLY products.



4.1 Define the term *cracking reaction*. (2)

4.2 Is the product in reaction **II** a PRIMARY, SECONDARY or TERTIARY haloalkane? Give a reason for the answer. (2)

4.3 Write down the:

4.3.1 STRUCTURAL FORMULA of compound **W** (3)

4.3.2 MOLECULAR formula of compound **U** (1)

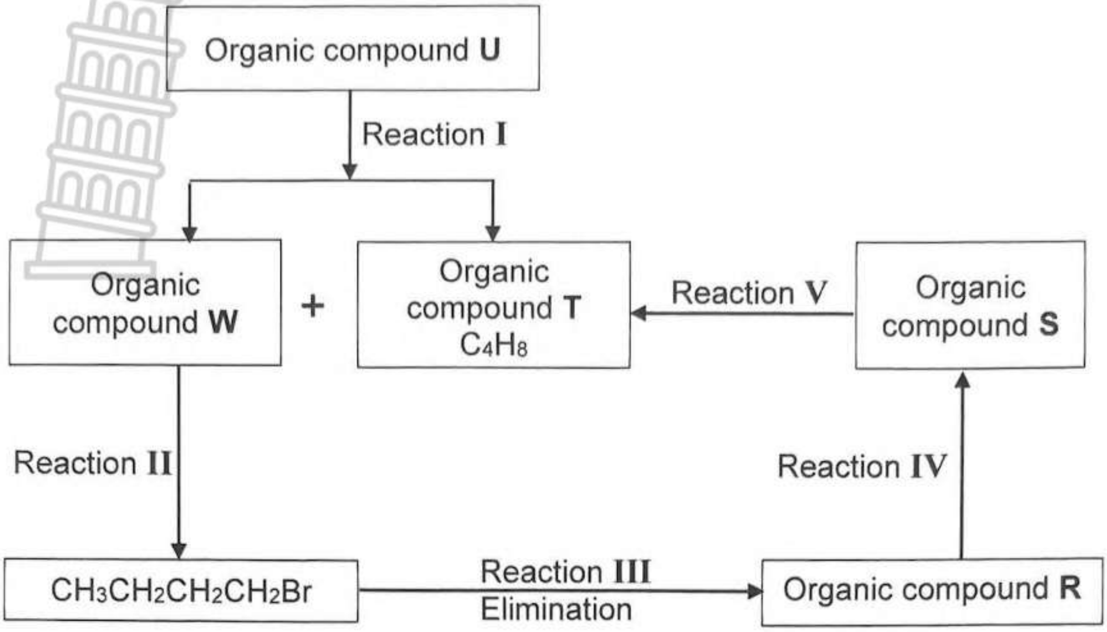
4.4 For reaction **II**, write down:

4.4.1 The NAME or FORMULA of the inorganic reactant (1)

4.4.2 The type of reaction (Choose from SUBSTITUTION, ADDITION or ELIMINATION.) (1)

4.4.3 ONE reaction condition (1)

The flow diagram on page 9 is redrawn below for easy reference.



4.5 Write down the TYPE of elimination in reaction **III**. (1)

4.6 Compounds **R** and **T** are positional isomers.

The inorganic reagents shown below are available for reactions **IV** and **V**.

Br_2	H_2SO_4(conc.)	NaOH(conc.)	HBr	H_2

Write down:

4.6.1 The balanced equation for reaction **IV**, using STRUCTURAL FORMULAE and the correct inorganic reagent shown above (5)

4.6.2 The balanced equation for reaction **V**, using STRUCTURAL formulae and the correct reagent shown above (3)

4.6.3 The IUPAC name of compound **T** (2)

[22]

QUESTION 5 (Start on a new page.)

5.1 The reaction between pure aluminium, $A\ell(s)$, and EXCESS hydrochloric acid, $HC\ell(aq)$, is used to investigate the factors that affect the rate of a reaction.

The balanced equation for the reaction is:

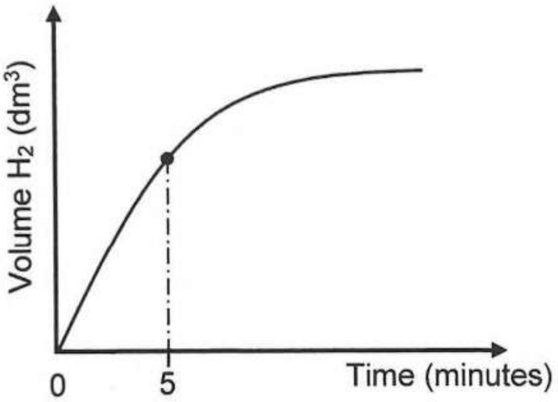
$$2A\ell(s) + 6HC\ell(aq) \rightarrow 2A\ell C\ell_3(aq) + 3H_2(g)$$

5.1.1 Define the term *reaction rate*. (2)

EXPERIMENT I

In this experiment, 1 mol·dm^{-3} $HC\ell$ solution reacts with a 0,5 g $A\ell$ strip from an aluminium roll at room temperature.

The graph of volume $H_2(g)$ versus time for this experiment, not drawn to scale, is shown below.



5.1.2 For the time interval t = 0 to t = 5 minutes, the average reaction rate for the formation of $H_2(g)$ is 0,033 dm^3·min^{-1}.

Calculate the mass of $A\ell$ present in the container at t = 5 minutes. Take the molar gas volume as 24,5 dm^3·mol^{-1}. (6)

Assume that the concentration of the $HC\ell(aq)$ stays constant for the duration of the reaction.

5.1.3 Use the collision theory to explain the change in the reaction rate from t = 0 to t = 5 minutes. (4)

EXPERIMENT II

Experiment I is repeated using a 2 mol·dm^{-3} $HC\ell$ solution.

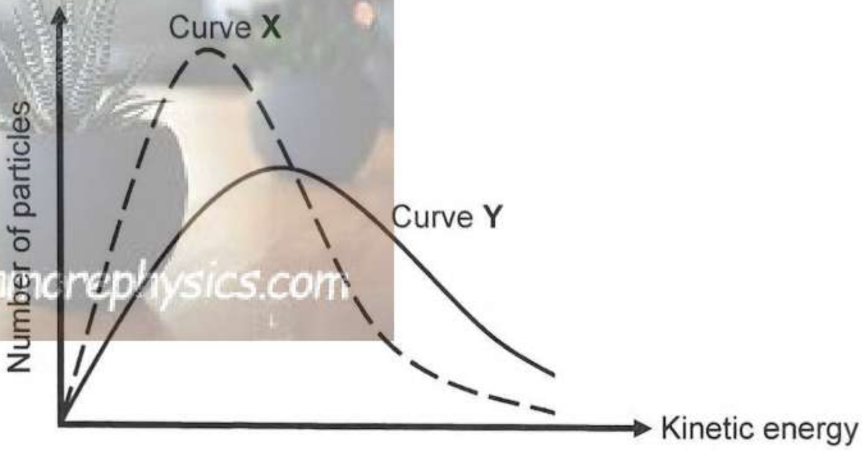
5.1.4 Redraw the above graph (NO numerical values need to be shown) in your ANSWER BOOK and label the curve **A**. On the same set of axes, draw the curve that will be obtained for Experiment II. Label this as curve **B**. (2)

EXPERIMENT III

Experiment I is repeated using 0,5 g pure powdered Aℓ.

5.1.5 How will the volume of $H_2(g)$ produced in Experiment III compare to that in Experiment I? Choose from GREATER THAN, LESS THAN or EQUAL TO. (1)

5.2 Curve **X** is the Maxwell Boltzmann distribution curve for a reaction under a set of reaction conditions. A change was made to one of the reaction conditions to obtain curve **Y**.



5.2.1 What change was made to obtain curve **Y**? (1)

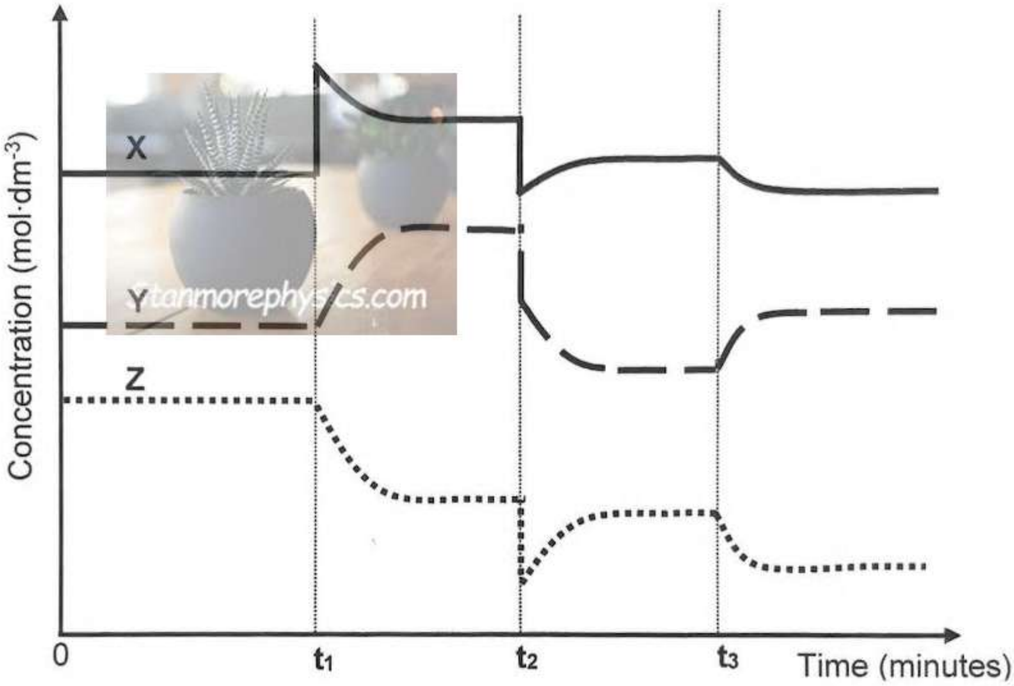
5.2.2 Give a reason for the answer to QUESTION 5.2.1. (1)
[17]

QUESTION 6 (Start on a new page.)

6.1 The reaction of carbon monoxide gas, CO(g), with oxygen gas, $O_2(g)$, is investigated. The reaction reaches equilibrium in a closed container at constant temperature T °C, according to the balanced equation:

$$2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g) \quad \Delta H < 0$$

Changes to the conditions of equilibrium are made at different times. The graph shows the results obtained. **X**, **Y** and **Z** represent the gases in the above reaction.



6.1.1 Define the term *chemical equilibrium*. (2)

Use the graph to answer the questions below.

6.1.2 At **t₁**, oxygen, $O_2(g)$, was added to the container. Write down the letter that represents $O_2(g)$. Choose from **X**, **Y** or **Z**. (1)

6.1.3 At **t₂**, the pressure is adjusted by changing the volume of the container. Was the pressure INCREASED or DECREASED? (1)

6.1.4 Give a reason for the answer to QUESTION 6.1.3. (1)

6.1.5 Write down the NAME or FORMULA of the gas that is represented by the letter **Z.** (1)

6.1.6 Give a reason for the answer to QUESTION 6.1.5. (1)

6.1.7 What change in temperature is made at **t₃**? Choose between INCREASED or DECREASED. (1)

6.1.8 Use Le Chatelier's principle to explain the answer to QUESTION 6.1.7. (3)

6.2 Carbon monoxide gas, $CO(g)$, reacts with water vapour, $H_2O(g)$, at T °C. The reaction reaches chemical equilibrium according to the balanced equation:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

Initially, 0,6 moles of $CO(g)$, 0,6 moles of $H_2O(g)$, 0,1 moles of carbon dioxide gas, $CO_2(g)$, and 0,1 moles of hydrogen gas, $H_2(g)$, were mixed and sealed in a 2 dm³ flask.

If the equilibrium constant, K_c, for this reaction at T °C is 4, calculate the mass of $CO(g)$ present in the flask at equilibrium. (9)

[20]

QUESTION 7 (Start on a new page.)

Hydrated potassium carbonate, $K_2CO_3 \cdot \mathbf{x}H_2O$, is a WEAK BASE. A solution is prepared by dissolving some of this solid in water.

7.1 Define the term *weak base*. (2)

7.2 Write down the formula of the conjugate acid of the carbonate ion, $CO_3^{2-}(aq)$. (1)

A hydrochloric acid solution, $HC\ell(aq)$, of concentration 0,1 mol·dm^{-3} is titrated with the prepared potassium carbonate solution, $K_2CO_3(aq)$, of unknown concentration.

The balanced equation for the reaction is:

$$K_2CO_3(aq) + 2HC\ell(aq) \rightarrow 2KC\ell(aq) + CO_2(g) + H_2O(\ell)$$

The results of the titration are given below.

	VOLUME OF $HC\ell(aq)$ USED (cm^3)	**$K_2CO_3(aq)$ IN BURETTE**		**VOLUME OF $K_2CO_3(aq)$ USED (cm^3)**
		INITIAL BURETTE READING (cm^3)	**FINAL BURETTE READING (cm^3)**	
Run 1	25	6,5	**p**	20,05
Run 2	25	**q**	48,3	20,15

7.3 Determine the value of:

7.3.1 **p** (1)

7.3.2 **q** (1)

7.4 METHYL ORANGE is used as the indicator. Explain why methyl orange is the most suitable indicator for this titration by referring to the pH at the equivalence point. (2)

7.5 Calculate the concentration of the K_2CO_3 solution. (5)

The above K_2CO_3 solution used in the titration, was prepared by completely dissolving 6,525 g of the hydrated potassium carbonate, $K_2CO_3 \cdot \mathbf{x}H_2O$, in 600 cm^3 water.

7.6 Calculate the value of **x** in the formula $K_2CO_3 \cdot \mathbf{x}H_2O$. (5)
[17]

QUESTION 8 (Start on a new page.)

8.1 Dilute hydrochloric acid, $HC\ell(aq)$, reacts with magnesium, $Mg(s)$, at 25 °C according to the following balanced equation:

$$Mg(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + H_2(g)$$

8.1.1 Use oxidation numbers for EACH of the reactants and explain why this reaction is a redox reaction. (2)

8.1.2 Write down the FORMULA of the oxidising agent in this reaction. (1)

It is observed that dilute hydrochloric acid does not react with copper, $Cu(s)$, at 25 °C.

8.1.3 Explain this observation by referring to the relative strengths of the reducing agents. (2)

8.1.4 Will dilute nitric acid, $HNO_3(aq)$, react with copper, $Cu(s)$, at 25 °C? Choose from YES or NO.

Explain the answer in terms of the relative strengths of the oxidising agents. (3)

8.2 A galvanic cell is represented by the following cell notation:

$$Pb(s) \mid Pb^{2+}(aq) \parallel Fe^{3+}(aq), Fe^{2+}(aq) \mid Pt(s)$$

8.2.1 Write down the balanced net ionic equation for this cell. (3)

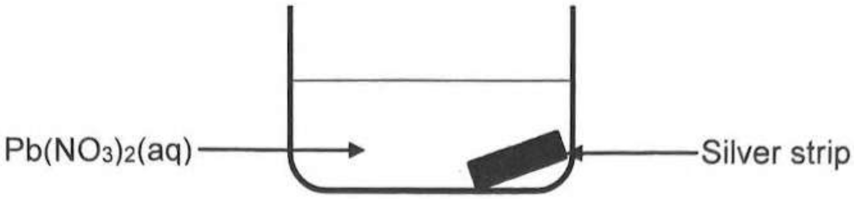
A stronger reducing agent is now used with the same oxidising agent under the same conditions.

8.2.2 How will this affect the initial emf of the cell? Choose from INCREASES, DECREASES or NO EFFECT. (1)

[12]

QUESTION 9 (Start on a new page.)

9.1 A strip of silver is added to a 1 mol·dm^{-3} solution of $Pb(NO_3)_2$ at 25 °C.

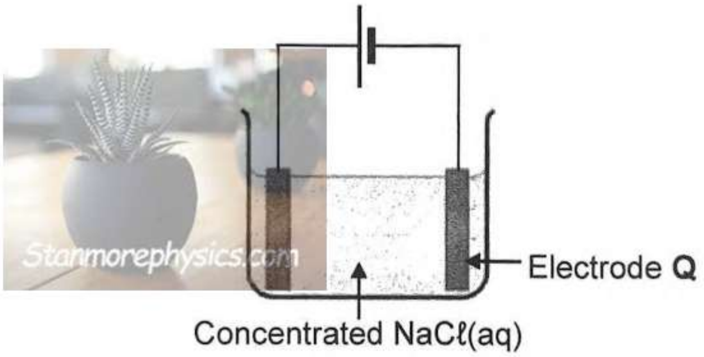


Consider the reaction below.

$$2Ag(s) + Pb^{2+}(aq) \rightarrow 2Ag^{+}(s) + Pb(s)$$

By means of a calculation, determine whether this reaction is SPONTANEOUS or NON-SPONTANEOUS. (5)

9.2 The simplified diagram below represents an electrolytic cell. The electrodes are made of carbon.



9.2.1 Define an *electrolyte*. (2)

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

9.2.3 Write down the NAMES or FORMULAE of the products formed at electrode **Q**. (2)

9.2.4 Explain the answer to QUESTION 9.2.3 by referring to the relative strengths of the oxidising agents involved. (2)
[13]

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 is the number of electrons/ *waar n die aantal elektrone is*

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

KEY/*SLEUTEL*

Atomic number
Atoomgetal

Electronegativity
Elektronegatiwiteit

Symbol
Simbool

Approximate relative atomic mass
Benaderde relatiewe atoommassa

29 1,9 Cu 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*

Half-reactions/*Halfreaksies*			$E^\ominus$ (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
$2H^+ + 2e^-$	$\rightleftharpoons$	**$H_2(g)$**	**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

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

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

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

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

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