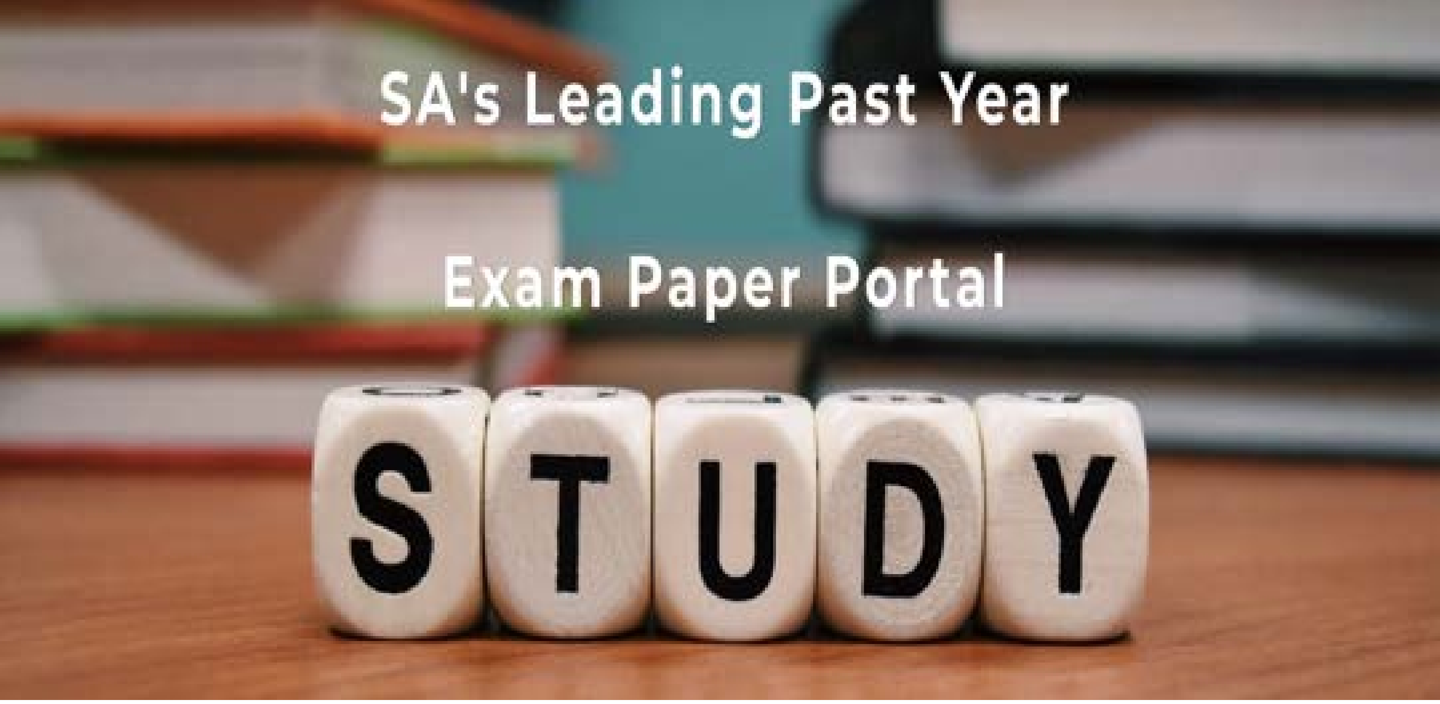
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SENIOR CERTIFICATE EXAMINATIONS/
NATIONAL SENIOR CERTIFICATE EXAMINATIONS

PHYSICAL SCIENCES: CHEMISTRY (P2)

2022

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 Which ONE of the following compounds has the LOWEST melting point?

A Hexane

B Ethane

C Butane

D Octane (2)

1.2 When $CH_2 = CH_2$ is converted to CH_3CH_3, the type of reaction is …

A hydration.

B hydrolysis.

C halogenation.

D hydrogenation. (2)

1.3 Which ONE of the following compounds in solution will change the colour of bromothymol blue?

A CH_3CH_2CHO

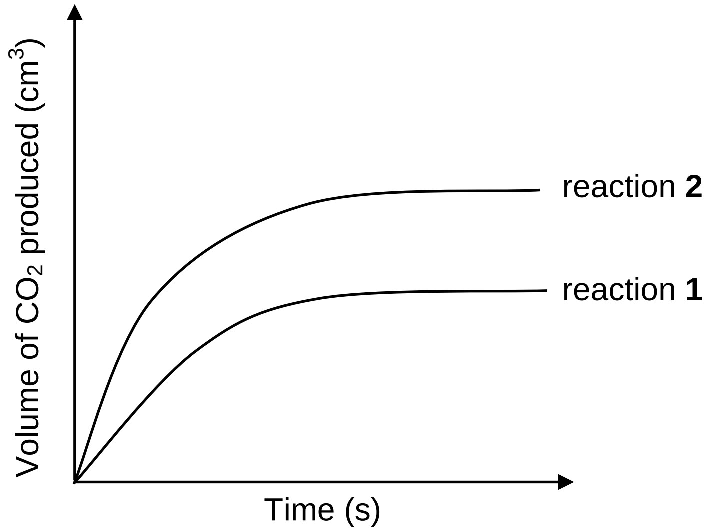
B CH_3CH_2COOH

C $CH_3CH_2COCH_3$

D $CH_3CH_2COOCH_3$ (2)

1.4 Two DIFFERENT samples of IMPURE $CaCO_3$ of EQUAL masses react with 0,1 mol·dm^{-3} H_2SO_4. Assume that the impurities do not react.

The graph below shows the volume of $CO_2(g)$ produced for each reaction.



When compared to reaction **2**, which ONE of the following statements BEST explains the curve obtained for reaction **1**?

A The temperature is higher in reaction **1**.

B The surface area is greater in reaction **2**.

C The amount of impurities is greater in reaction **2**.

D The amount of impurities is greater in reaction **1**. (2)

1.5 The equation below represents a hypothetical reaction.

$$A(g) + B(g) \rightleftharpoons C(g) \qquad \Delta H = -50\ kJ\cdot mol^{-1}$$

The activation energy for the REVERSE reaction is 110 kJ·mol^{-1}.

Which ONE of the following is the activation energy (in kJ·mol^{-1}) for the FORWARD reaction?

A 50

B 60

C 110

D 160 (2)

1.6 A reaction reaches equilibrium at 25 °C in a flask according to the following balanced equation:

$$\underset{\text{pink}}{Co(H_2O)_6^{2+}(aq)} + 4C\ell^-(aq) \rightleftharpoons \underset{\text{blue}}{CoC\ell_4^{2-}(aq)} + 6H_2O(\ell) \qquad \Delta H > 0$$

Which ONE of the following will change the colour of the mixture from pink to blue?

A Adding water

B Cooling the flask

C Adding NaOH(aq)

D Adding $NH_4C\ell(aq)$ (2)

1.7 Dilute nitric acid is added to distilled water at 25 °C.

How will this affect the hydronium ion concentration $[H_3O^+]$ and the ionisation constant (K_w) of water at 25 °C?

	$[H_3O^+]$	K_w
A	Increases	Increases
B	Increases	Decreases
C	Increases	Remains the same
D	Remains the same	Remains the same

(2)

1.8 Consider the ionisation reactions **I** and **II**.

I $H_2PO_4^- + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + \mathbf{X}$

II $\mathbf{X} + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + \mathbf{Y}$

Which ONE of the following combinations represents the formulae of **X** and **Y** respectively?

	X	Y
A	HPO_4^{2-}	PO_4^{3-}
B	HPO_4^{2-}	H_3PO_4
C	H_3PO_4	PO_4^{3-}
D	HPO_4^{2-}	$H_2PO_4^-$

(2)

1.9 An electrochemical cell was set up using a $Hg(\ell)|Hg^{2+}(aq)$ half-cell and another half-cell under standard conditions.

Which ONE of the following half-cells, when connected to the $Hg(\ell)|Hg^{2+}(aq)$ half-cell, will result in the HIGHEST cell potential?

A $A\ell(s)|A\ell^{3+}(aq)$

B $Zn(s)|Zn^{2+}(aq)$

C $Co(s)|Co^{2+}(aq)$

D $Pt(s)|H_2(g)|H^+(aq)$ (2)

1.10 The following reaction takes place in an electrochemical cell:

$$CuC\ell_2(aq) \rightarrow Cu(s) + C\ell_2(g)$$

Which ONE of the following is CORRECT for this cell?

A It is a galvanic cell.

B A power source is needed.

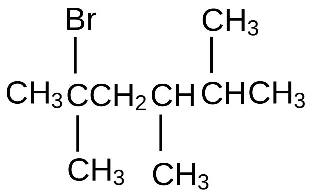
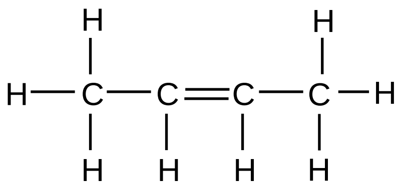
C The reaction is spontaneous.

D Copper acts as the oxidising agent. (2)

[20]

QUESTION 2 (Start on a new page.)

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

A	 $CH_3\overset{Br}{\underset{CH_3}{C}}CH_2\underset{CH_3}{CH}\overset{CH_3}{CH}CH_3$	**B**	 $H-\overset{H}{\underset{H}{C}}-\underset{H}{C}=\underset{H}{C}-\overset{H}{\underset{H}{C}}-H$
C	Pent-2-ene	**D**	$CH_3CH_2CH_2CHO$
E	Butan-2-one	**F**	4,4-dimethylpent-2-yne
G	Butane	**H**	$CH_3CH_2CH_2COOH$

2.1 Write down the LETTER that represents a compound that:

2.1.1 Is a ketone (1)

2.1.2 Has the general formula C_nH_{2n-2} (1)

2.1.3 Is an isomer of 2-methylbut-2-ene (1)

2.1.4 Has the same molecular formula as ethyl ethanoate (1)

2.2 Write down the:

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

2.2.2 STRUCTURAL FORMULA of compound **F** (3)

2.3 For compound **D**, write down the:

2.3.1 Homologous series to which it belongs (1)

2.3.2 NAME of its functional group (1)

2.3.3 STRUCTURAL FORMULA of its functional isomer (2)

2.4 For compound **G**, write down:

2.4.1 The IUPAC name of a chain isomer (2)

2.4.2 A balanced equation, using molecular formulae, for its complete combustion (3)

[19]

QUESTION 3 (Start on a new page.)

Learners investigate factors that influence the boiling points of organic compounds. The boiling points of some organic compounds obtained are shown in the table below.

COMPOUND		MOLECULAR MASS ($g{\cdot}mol^{-1}$)	BOILING POINT (°C)
A	Propane	44	- 42
B	Butane	58	- 0,5
C	Pentane	72	36
D	Methylbutane	72	28
E	Ethanol	46	78
F	Ethanal	44	20

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

3.2 The boiling points of compounds **A**, **B** and **C** are compared.

3.2.1 How do the boiling points vary from compound **A** to compound **C**?

Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

3.2.2 Explain the answer to QUESTION 3.2.1. (3)

3.3 The boiling points of compounds **B**, **C** and **D** are compared.

Is this a fair comparison?

Choose from YES or NO. Give a reason for the answer. (2)

3.4 The boiling points of compounds **E** and **F** are compared.

3.4.1 State the independent variable for this comparison. (1)

3.4.2 Write down the name of the strongest Van der Waals force present in compound **F**. (1)

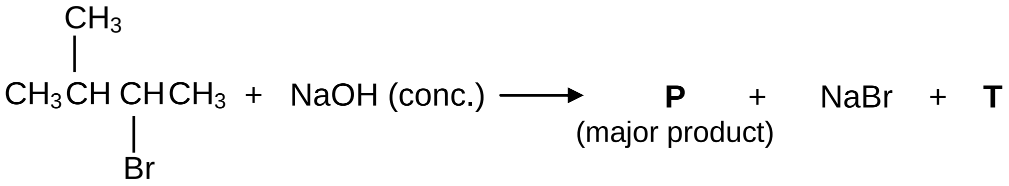
3.5 Which compound, **D** or **E**, has a higher vapour pressure? Give a reason for the answer. (2)

[12]

QUESTION 4 (Start on a new page.)

4.1 Study the following incomplete equations for organic reactions **I** and **II**.

Compounds **P** and **Q** are ORGANIC compounds and **T** is an INORGANIC compound.

I	 $CH_3\overset{\overset{\displaystyle CH_3}{\vert}}{C}H\underset{\underset{\displaystyle Br}{\vert}}{C}HCH_3 + NaOH\ (conc.) \longrightarrow \underset{\text{(major product)}}{\mathbf{P}} + NaBr + \mathbf{T}$
II	CH_3COOH + compound **Q** → butyl ethanoate + H_2O

For reaction **I**, write down the:

4.1.1 Type of reaction that takes place (1)

4.1.2 IUPAC name of compound **P** (2)

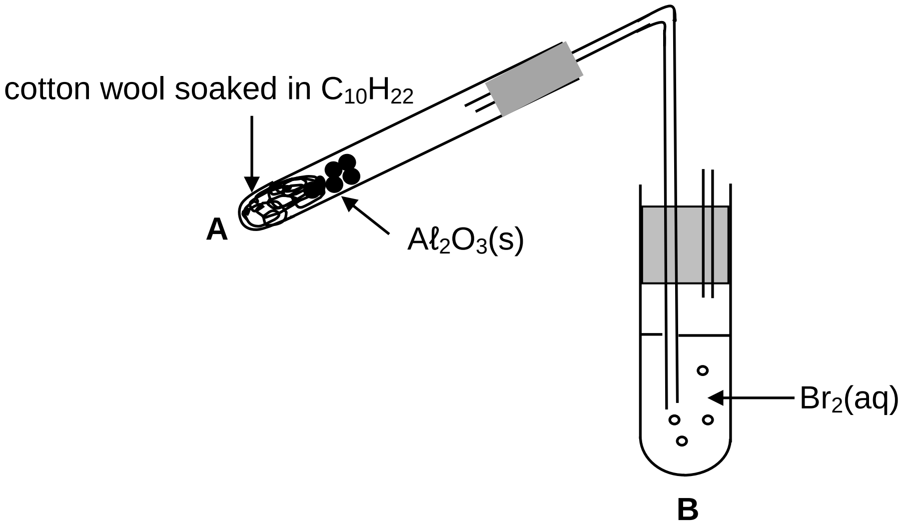
4.1.3 NAME or FORMULA of compound **T** (1)

For reaction **II**, write down:

4.1.4 TWO reaction conditions needed (2)

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

4.2 The cracking of a long chain hydrocarbon, $C_{10}H_{22}$, takes place in test tube **A**, as shown below.



Two STRAIGHT CHAIN organic compounds, **X** and **Z**, are produced in test tube **A** according to the following balanced equation:

$$C_{10}H_{22}(\ell) \rightarrow 2\mathbf{X}(g) + \mathbf{Z}(g)$$

4.2.1 State the function of the $A\ell_2O_3(s)$ in test tube **A**. (1)

The organic compounds, **X** and **Z**, are now passed through bromine water, $Br_2(aq)$, at room temperature in test tube **B**. Only compound **X** reacts with the bromine water.

4.2.2 Apart from gas bubbles being formed, state another observable change in test tube **B**. (1)

4.2.3 Write down the TYPE of reaction that takes place in test tube **B**. (1)

4.2.4 Write down the molecular formula of compound **Z**. (3)

4.2.5 Write down the STRUCTURAL FORMULA of compound **X**. (3)

[17]

QUESTION 5 (Start on a new page.)

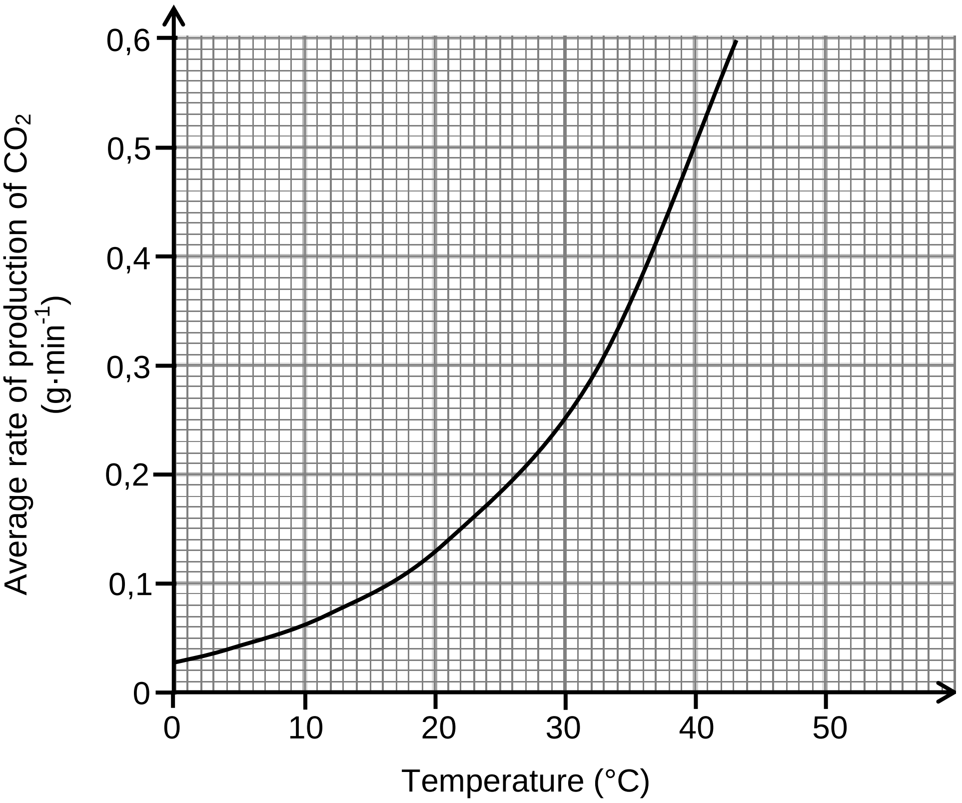
Learners use the reaction of $MgCO_3(s)$ with EXCESS dilute HCℓ(aq) to investigate the relationship between temperature and the rate of a chemical reaction.

The balanced equation for the reaction is:

$$MgCO_3(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + CO_2(g) + H_2O(\ell)$$

The results obtained are represented in the graph below.

Graph of average rate of production of CO_2 (in g·min^{-1}) versus temperature



5.1 Define the term *rate of reaction*. (2)

5.2 State TWO conditions that must be kept constant during this investigation. (2)

5.3 Use the collision theory to explain the relationship shown in the graph. (4)

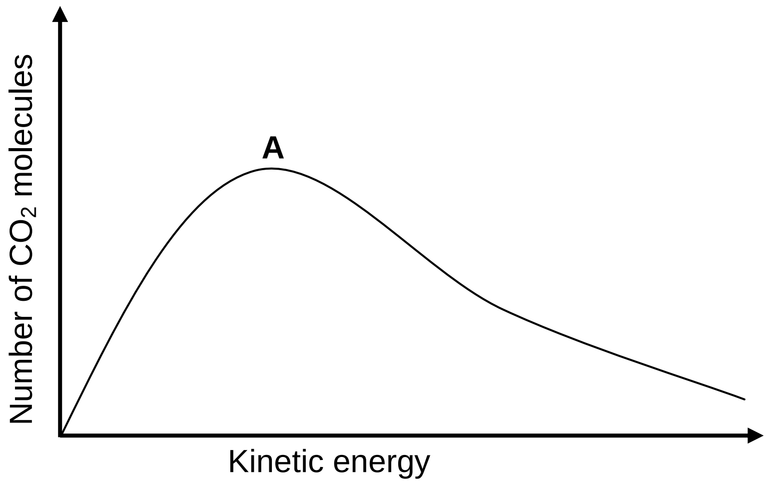
5.4 The learners obtained the graph above using 5 g $MgCO_3(s)$ with EXCESS HCℓ at 40 °C.

Calculate the:

5.4.1 Time taken for the reaction to run to completion (6)

5.4.2 Molar gas volume at 40 °C if 1,5 dm^3 CO_2 is collected in a syringe (2)

5.5 The graph below represents the Maxwell-Boltzmann distribution curve for $CO_2(g)$ at 40 °C.



Redraw the graph above in the ANSWER BOOK. Clearly label the curve as **A**.

On the same set of axes, sketch the curve that will be obtained for the $CO_2(g)$ at 20 °C. Label this curve as **B**. (2)

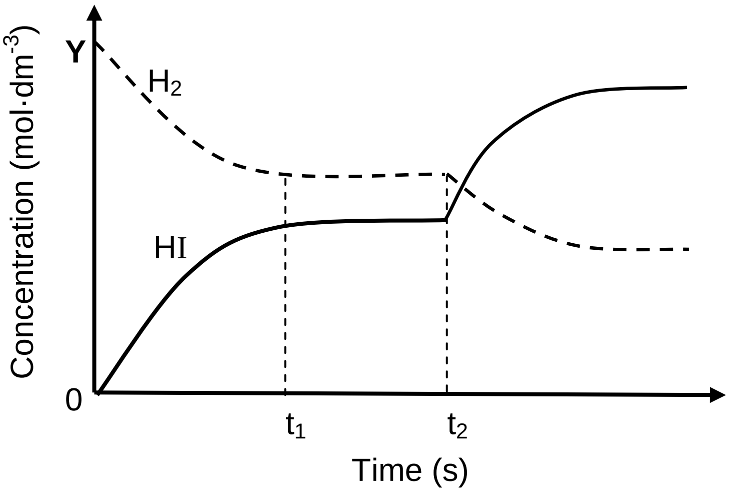
[18]

QUESTION 6 (Start on a new page.)

6.1 Initially, 4 moles $H_2(g)$ and 4 moles $I_2(g)$ are allowed to react in a sealed 2 dm^3 flask according to the following balanced equation:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H < 0$$

The graph below shows the concentrations of $H_2(g)$ and HI(g) versus time during the reaction.



6.1.1 Write down the value of **Y**. (1)

6.1.2 State Le Chatelier's principle. (2)

6.1.3 Changes were made to the temperature of the flask at time t_2.

Was the flask HEATED or COOLED? (1)

6.1.4 Fully explain the answer to QUESTION 6.1.3. (3)

6.2 The equation below represents the reversible reaction that takes place when $NO_2(g)$ is converted to $N_2O_4(g)$.

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

Initially, **x** mol of $NO_2(g)$ is sealed in a 1 dm^3 container at 350 K. When equilibrium is established at this temperature, 0,81 mol $N_2O_4(g)$ is present in the container.

6.2.1 Write down the meaning of the term *reversible reaction*. (1)

6.2.2 Show that the equilibrium constant for this reaction is given by $\frac{0{,}81}{(x-1{,}62)^2}$. (5)

0,79 moles of $N_2O_4(g)$ is now added to the equilibrium mixture above. When the NEW equilibrium is established at 350 K, it is found that the amount of $NO_2(g)$ increased by 1,2 moles.

6.2.3 Calculate the value of **x**. (6)

[19]

QUESTION 7 (Start on a new page.)

7.1 Two acids, HX and HY, of EQUAL CONCENTRATIONS are compared. The pH of HX is 2,7 and the pH of HY is 0,7.

7.1.1 Define an *acid* in terms of the Lowry-Brønsted theory. (2)

7.1.2 Which acid, HX or HY, is STRONGER? Give a reason for the answer. (2)

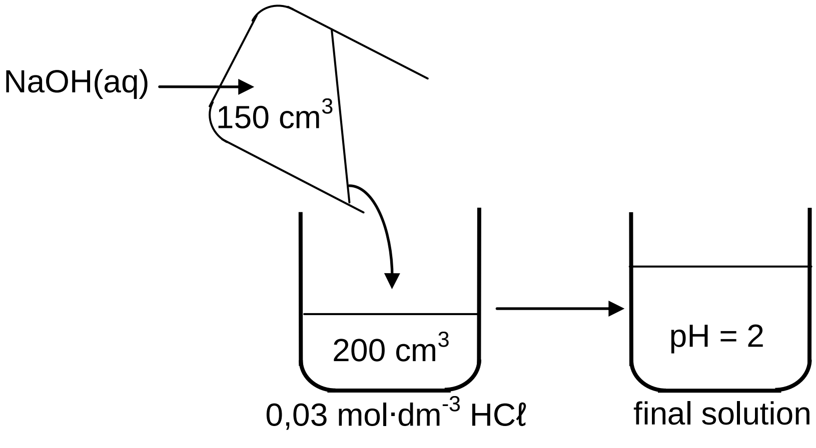
7.1.3 Acid HX ionises in water according to the following equation:

$$HX(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + X^-(aq)$$

The K_a value for the reaction is $1,8 \times 10^{-5}$ at 25 °C.

Is the concentration of the hydronium ions HIGHER THAN, LOWER THAN or EQUAL TO the concentration of HX? Give a reason for the answer. (2)

7.2 Learners add 150 cm^3 of a sodium hydroxide solution, NaOH, of unknown concentration to 200 cm^3 of a 0,03 $mol{\cdot}dm^{-3}$ hydrochloric acid solution, HCℓ, as illustrated below. They find that the pH of the final solution is 2. Assume that the volumes are additive.



The balanced equation for the reaction is:

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

Calculate the:

7.2.1 Concentration of the H_3O^+ ions in the final solution (3)

7.2.2 Initial concentration of the NaOH(aq) (7)

[16]

QUESTION 8 (Start on a new page.)

8.1 An electrochemical cell is set up using an aluminium rod, Aℓ, and a gas **X**.

The initial emf measured under standard conditions is 2,89 V.

8.1.1 State the standard conditions under which this cell operates. (3)

8.1.2 Use a calculation to identify gas **X**. (5)

8.1.3 Write down the FORMULA of the reducing agent in this cell. (1)

8.1.4 Write down the half-reaction that takes place at the cathode. (2)

8.1.5 Write down the cell notation for this cell. (3)

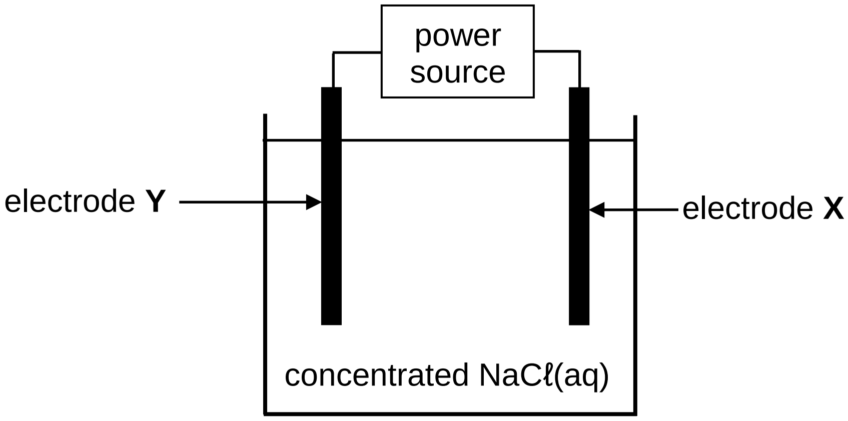
8.2 Which container, ZINC or COPPER, will be more suitable to store an aqueous solution of nickel ions, Ni^{2+}?

Refer to the Table of Standard Reduction Potentials to fully explain the answer in terms of the relative strengths of reducing agents. (4)

[18]

QUESTION 9 (Start on a new page.)

The simplified diagram below represents an electrochemical cell used for the electrolysis of a concentrated sodium chloride solution, NaCℓ(aq). **X** and **Y** are carbon electrodes.



9.1 Define the term *electrolysis*. (2)

9.2 Chlorine gas, $C\ell_2(g)$, is released at electrode **X**.

Write down the:

9.2.1 Letter (**X** or **Y**) of the electrode where oxidation takes place (1)

9.2.2 Half-reaction that takes place at electrode **Y** (2)

9.2.3 Direction in which electrons flow in the external circuit

Choose from **X** to **Y** OR **Y** to **X**. (1)

9.2.4 Balanced equation for the net (overall) cell reaction that takes place in the cell (3)

9.3 How will the pH of the electrolyte change during the reaction?

Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

9.4 Give a reason for the answer to QUESTION 9.3. (1)
[11]

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* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a v_a}{c_b v_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ 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* $E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	
$n = \frac{Q}{e}$ or/*of* $n = \frac{Q}{q_e}$	

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
$2H^+ + 2e^-$	$\rightleftharpoons$	**$H_2(g)$**	**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

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

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

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