basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

NOVEMBER 2022

MARKS: 150

TIME: 3 hours

This question paper consists of 14 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 terms describes hydrocarbons that contain only single bonds?

        A   Isomers

        B   Saturated

        C   Unsaturated

        D   Homologous series   (2)

1.2   Which ONE of the following combinations correctly indicates the STRONGEST intermolecular forces found in ethanoic acid and methyl propanoate respectively?

	ETHANOIC ACID	METHYL PROPANOATE
A	Hydrogen bonds	Hydrogen bonds
B	Dipole-dipole forces	London forces
C	Hydrogen bonds	London forces
D	Hydrogen bonds	Dipole-dipole forces

(2)

1.3   A test tube contains a liquid hydrocarbon.

        When bromine water (Br_2) is added to the test tube, the mixture decolourises IMMEDIATELY.

        Which ONE of the following combinations correctly identifies the COMPOUND and the TYPE OF REACTION that takes place in the test tube?

|	COMPOUND	TYPE OF REACTION
A	Hexane	Addition
B	Hexane	Substitution
C	Hex-2-ene	Addition
D	Hex-2-ene	Substitution

(2)

1.4   Which ONE of the following statements is the CORRECT definition for the rate
        of a reaction?

        A   The time taken for the reaction to take place

        B   The speed at which the reaction takes place

        C   The rate of change in concentration of the products or reactants

        D   The rate of change in concentration of the products or reactants per unit
              time   (2)

1.5   Consider the balanced equation for the reaction between magnesium powder
        and EXCESS dilute hydrochloric acid, $HC\ell(aq)$:

$$Mg(s) \ + \ 2HC\ell(aq) \ \rightarrow \ MgC\ell_2(aq) \ + \ H_2(g)$$
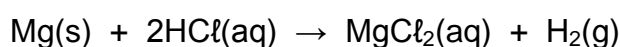
        Which ONE of the following will NOT increase the rate of this reaction?

        A   Increasing the volume of $HC\ell(aq)$
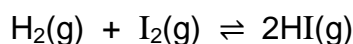
        B   Increasing the temperature of $HC\ell(aq)$

        C   Increasing the concentration of $HC\ell(aq)$

        D   Adding more magnesium powder   (2)

1.6   Two identical sealed gas jars, **R** and **S**, initially contain gases as shown
        below.
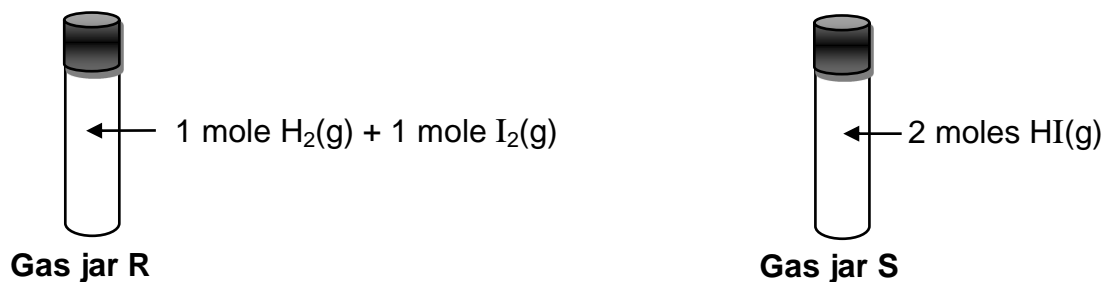
Gas jar R   **Gas jar S**

        Equilibrium is reached in both gas jars at 500 °C according to the following
        balanced equation:

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

        Which ONE of the following statements is TRUE at equilibrium?

        A   **S** will contain 1 mole of $I_2(g)$.

        B   **R** will contain a larger amount of $I_2(g)$ than **S**.

        C   **R** and **S** will contain the same amount of $HI(g)$.

        D   **S** will contain a larger amount of $HI(g)$ than **R**.   (2)

1.7   Which ONE of the following salts, when dissolved in water, will NOT change the pH of the water?

A Na_2CO_3

B $(COO)_2Na_2$

C NH_4Cl

D $NaCl$ (2)

1.8   A dilute acid is titrated against a potassium hydroxide solution, KOH(aq).

        At the equivalence point the pH is 7.

        Which ONE of the following combinations correctly identifies the acid and the MOST SUITABLE indicator for this titration?

	ACID	INDICATOR
A	$(COOH)_2(aq)$	Phenolphthalein
B	$(COOH)_2(aq)$	Bromothymol blue
C	$HCl(aq)$	Phenolphthalein
D	$HCl(aq)$	Bromothymol blue

                                                                                                    (2)

1.9   Which ONE of the following statements is TRUE for an oxidising agent?
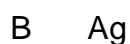
A   It gains electrons.

B   It causes another species in the reaction to be reduced.

C   Its oxidation number does not change during a chemical reaction.

D   Its oxidation number increases during a chemical reaction.   (2)

1.10   Which ONE of the following metals will reduce Cd^{2+}(aq) to Cd(s), but will NOT reduce Mn^{2+}(aq) to Mn(s)?

A   Zn

B   Ag

C   Ni

D   Mg   (2)
                                                                                                   [20]

QUESTION 2 (Start on a new page.)

A to **F** in the table below represent six organic compounds.

A	CH_3 | CH_3—C—CH—Br | | CH_3—CH_2 CH_2 | CH_3	**B**	H | H—C—H | H CH_3—C—C≡C—C—H | | CH_3 H

C	O
	          ||
	 CH_3—CH_2—CH_2—C
	            |
	           H
		D	O
			        ||
			 CH_3—CH_2—C
			          |
			         CH_3

E	O
	          ||
	 CH_3—CH_2—CH_2—C
	            |
	           OH
		F	CH_3—CH_2—CH_2—CH_2
			                   |
			                   OH

2.1 Write down the:

     2.1.1   Letters that represent TWO organic compounds that are isomers of each other   (1)

     2.1.2   Type of isomers (CHAIN, FUNCTIONAL or POSITIONAL) identified in QUESTION 2.1.1   (1)

     2.1.3   GENERAL FORMULA of the homologous series to which compound **B** belongs   (1)

     2.1.4   NAME of the functional group of compound **F**   (1)

2.2 Write down the IUPAC name of:

     2.2.1   Compound **A**   (3)

     2.2.2   Compound **B**   (2)

     2.2.3   Compound **C**   (2)

2.3 Compound **F** reacts with a carboxylic acid to form compound **S** in the presence of a strong acid.

     2.3.1   Write down the type of reaction that takes place.   (1)

     Compound **S** has an EMPIRICAL FORMULA of C_3H_6O and a molecular mass of 116 g·mol^{-1}.

     2.3.2   Write down the MOLECULAR FORMULA of the carboxylic acid.   (3)

                                                                     [15]

QUESTION 3 (Start on a new page.)

3.1   The melting points of some organic compounds are given in the table below.

COMPOUND	IUPAC NAME	MELTING POINTS (^{o}C)
A	Propanone	-95,4
B	Butanone	-86,9
C	Pentan-2-one	-77,8
D	3-methylbutanone	-92

3.1.1   To which homologous series do the above compounds belong?   (1)

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

3.1.2   Write down the controlled variable for this comparison.   (1)

The melting points of compounds **C** and **D** are compared.

3.1.3   Fully explain the difference in the melting points of these two compounds.   (4)

3.2   The table below shows the results obtained from an experiment to determine the vapour pressure of different STRAIGHT CHAIN primary alcohols at 300 K.

ALCOHOL	VAPOUR PRESSURE (kPa)
CH_3OH	16,8
C_2H_5OH	7,88
C_3H_7OH	2,8
C_4H_9OH	0,91
$C_5H_{11}OH$	0,88
$C_6H_{13}OH$	0,124

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

3.2.2   Write down a suitable conclusion for this investigation.   (2)

3.2.3   Write down the IUPAC name of the alcohol with the HIGHEST boiling point.   (3)
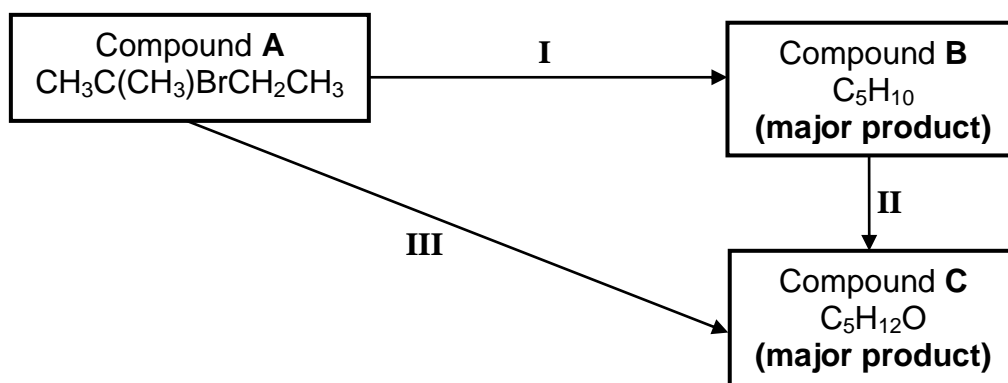
3.2.4   The experiment is now repeated at 320 K.

Will the vapour pressure of each compound INCREASE, DECREASE or REMAIN THE SAME?   (1)

[14]

QUESTION 4 (Start on a new page.)

The flow diagram below shows how compound **A** can be used as a starting reactant to prepare two different compounds.

I, **II** and **III** represent three organic reactions.

```
┌─────────────────────────┐                      ┌──────────────────────┐
│   Compound A            │         I            │   Compound B         │
│ CH₃C(CH₃)BrCH₂CH₃       │ ───────────────────▶ │   C₅H₁₀             │
│                         │                      │   (major product)    │
└─────────────────────────┘                      └──────────────────────┘
            │                                                │
            │                                              II │
            │        III                                     ▼
            │                                     ┌──────────────────────┐
            └───────────────────────────────────▶│   Compound C         │
                                                  │   C₅H₁₂O             │
                                                  │   (major product)    │
                                                  └──────────────────────┘
```

Compound **A**: $CH_3C(CH_3)BrCH_2CH_3$

Compound **B**: C_5H_{10} (major product)

Compound **C**: $C_5H_{12}O$ (major product)

4.1   Is compound **A** a PRIMARY, SECONDARY or TERTIARY haloalkane? Give a reason for the answer. (2)

4.2   Consider reaction **I**.

    4.2.1   Besides heat, write down the other reaction condition needed. (1)

    4.2.2   Write down the type of reaction that takes place. (1)

    4.2.3   Using STRUCTURAL FORMULAE for the organic compounds, write down a balanced equation for the reaction. (5)

4.3   Consider reaction **II**.

    Write down the:

    4.3.1   STRUCTURAL FORMULA of compound **C** (2)

    4.3.2   NAME or FORMULA of the inorganic reagent needed (1)

    4.3.3   Type of addition reaction that takes place (1)

4.4   Consider reaction **III**.

    4.4.1   Write down of the type of reaction that takes place. (1)

    4.4.2   Besides heat, write down the other reaction condition needed. (1)

[15]

QUESTION 5 (Start on a new page.)

Three experiments, **A**, **B** and **C**, are carried out to investigate some of the factors that affect the rate of decomposition of hydrogen peroxide, $H_2O_2(\ell)$.

The balanced equation for the reaction is:

$$2H_2O_2(\ell) \rightarrow 2H_2O(\ell) + O_2(g)$$
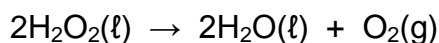
Identical samples of hydrogen peroxide are used in each experiment.

The conditions used in each experiment are summarised in the table below.

EXPERIMENT	TEMPERATURE (°C)	
A	25	Without catalyst
B	25	With catalyst
C	35	Without catalyst

5.1 In which experiment, **A** or **B**, is the reaction rate higher? Use the collision theory to explain the answer. (4)

5.2 The Maxwell-Boltzmann distribution curves, **X** and **Y**, for two of the above experiments are shown below.
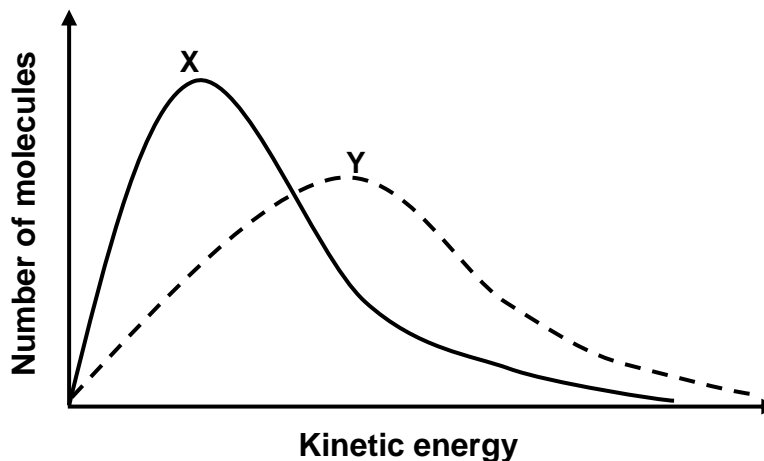
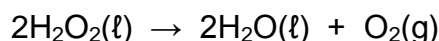Identify the curve (**X** or **Y**) that represents experiment **C**. (2)

5.3   The volume of oxygen gas, $O_2(g)$, produced in experiment **B** during the first 3,6 s is collected in a syringe, as shown below.
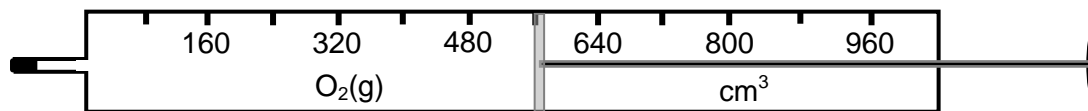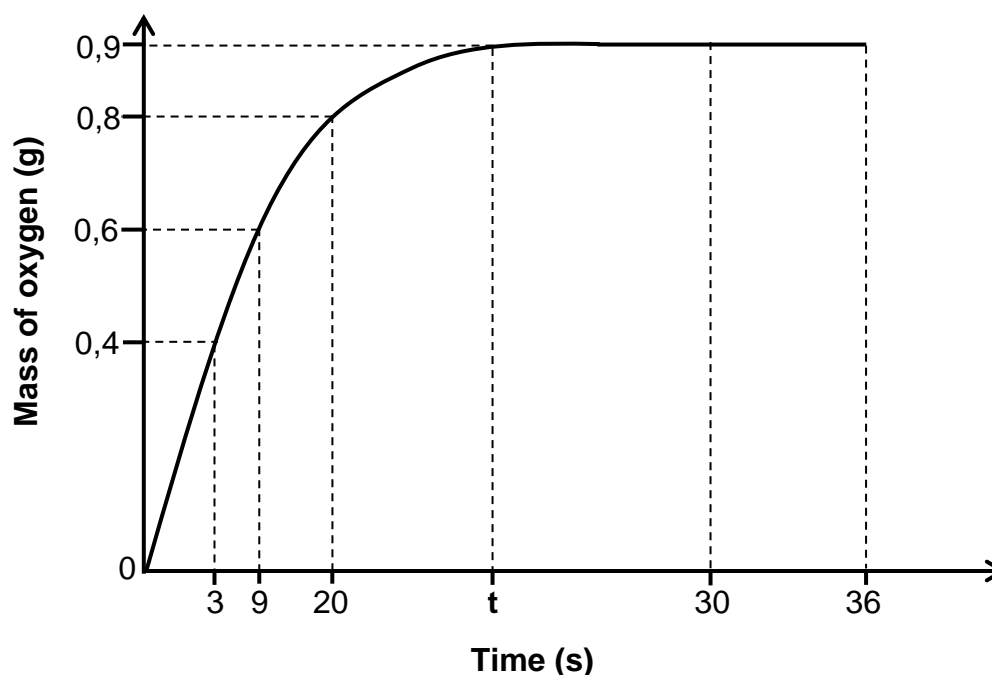

5.3.1   Write down the volume of $O_2(g)$ collected in the syringe.   (2)

The balanced equation for the reaction is:

$$2H_2O_2(\ell) \rightarrow 2H_2O(\ell) + O_2(g)$$

5.3.2   Calculate the mass of water, $H_2O(\ell)$, that was produced during the first 3,6 s. Take the molar gas volume to be 24 000 $cm^3 \cdot mol^{-1}$ at 25 °C.   (4)

5.4   The graph below, NOT drawn to scale, is obtained for the mass of oxygen gas produced over a period of time in experiment **A**.

Use the information in the graph to answer the following questions:

5.4.1   Write down the rate of production of oxygen gas for the interval 30 s to 36 s.   (1)

5.4.2   Will the rate of the reaction in the interval 3 s to 9 s be GREATER THAN, SMALLER THAN or EQUAL TO the rate of the reaction in the interval 9 s to 20 s?   (1)

5.4.3   The average rate of decomposition of hydrogen peroxide is $2,1 \times 10^{-3}$ mol·s^{-1}.

Calculate the value of time **t** on the graph.   (5)

[19]

QUESTION 6 (Start on a new page.)

Carbon, C(s), reacts with sulphur, S(g), according to the following balanced equation:

$$C(s) + 2S(g) \rightleftharpoons CS_2(g) \qquad \Delta H > 0$$

The system reaches equilibrium at temperature T in a sealed 2 dm³ container.

The K_c value is 9,4 at temperature T.

6.1   State Le Chatelier's principle.   (2)

At equilibrium, 1 mole of carbon disulphide, $CS_2(g)$, is present in the container.

6.2   Calculate the concentration of S(g) present at equilibrium.   (4)

The volume of the container is now DOUBLED at temperature T. After a while, a NEW equilibrium is established.

6.3   How will the amount of S(g) change as this new equilibrium is established? Choose from INCREASES, DECREASES or REMAINS THE SAME.   (1)

6.4   Explain the answer to QUESTION 6.3 in terms of Le Chatelier's principle.   (3)

6.5   If the concentration of $CS_2(g)$ CHANGES by **x** mol·dm⁻³, write down an expression for the equilibrium constant, K_c, in terms of **x**.

        Show ALL your workings. NO simplification or solving for **x** is required.   (5)

6.6   The reaction rate-time graph below represents further changes made to the equilibrium mixture. The volume of the container is kept constant.
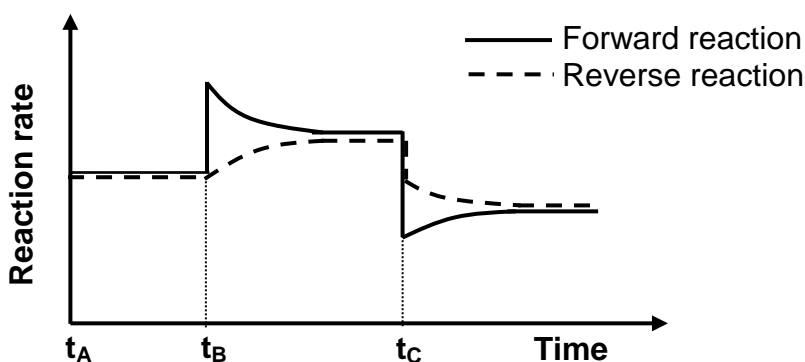
        6.6.1   What do the parallel lines between t_A and t_B represent?   (1)

        6.6.2   What change was made to the equilibrium mixture at t_B?   (1)
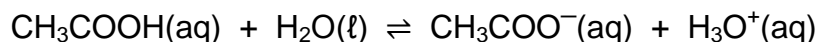
        6.6.3   Give a reason for the sudden change in the reaction rate at t_C.   (1)

        6.6.4   Fully explain the answer to QUESTION 6.6.3.   (3)

                                                                                 [21]

QUESTION 7 (Start on a new page.)

7.1   Ethanoic acid is a weak acid that reacts with water according to the following balanced equation:

$$CH_3COOH(aq) + H_2O(\ell) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$$

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

7.1.2   Give a reason why ethanoic acid is classified as a WEAK acid.   (1)

7.1.3   Write down the formulae of the TWO bases in the equation above.   (2)

7.2   A flask contains $300 \ cm^3$ of dilute sodium hydroxide, NaOH(aq), of concentration $0,167 \ mol \cdot dm^{-3}$.

7.2.1   Calculate the number of moles of sodium hydroxide in the flask.   (3)

Ethanoic acid of volume $500 \ cm^3$ and of unknown concentration, **X**, is now added to this flask to give a solution of volume $800 \ cm^3$.

It is found that the pH of the mixture is 11,4.

The balanced equation for the reaction is:

$$NaOH(aq) + CH_3COOH(aq) \rightarrow CH_3COONa(aq) + H_2O(\ell)$$
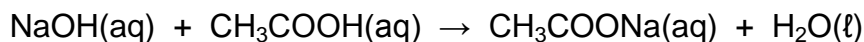
Calculate the:

7.2.2   Concentration of the OH^-(aq) in the mixture   (4)

7.2.3   Initial concentration, **X**, of the ethanoic acid solution   (6)

[18]

QUESTION 8 (Start on a new page.)

8.1   A piece of zinc (Zn) is placed in a test tube containing an acidified
        permanganate solution, MnO_4^-(aq). After some time, it is found that a redox
        reaction has taken place.

        Use the Table of Standard Reduction Potentials to answer the following
        questions:

        8.1.1   Write down the NAME or FORMULA of the reducing agent.   (1)

        8.1.2   Refer to the relative strengths of the OXIDISING AGENTS to
                  explain why a redox reaction has taken place.   (3)

8.2   A standard electrochemical cell is set up as shown below.
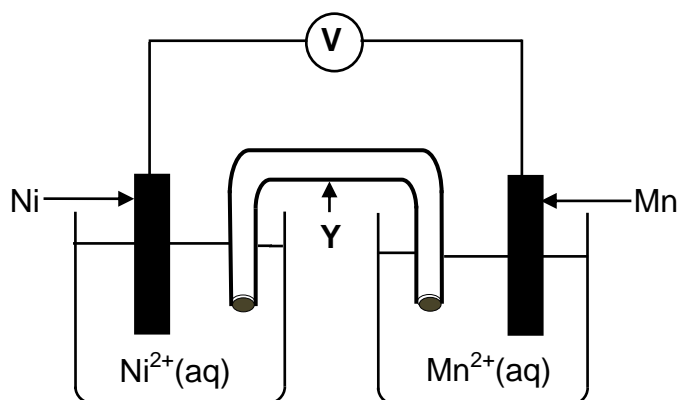
        8.2.1   Write down the function of component **Y**.   (1)

        8.2.2   In which direction will electrons flow in the external circuit? Choose
                  from 'Ni to Mn' OR 'Mn to Ni'.   (2)

        8.2.3   Calculate the initial emf of this cell.   (4)

        8.2.4   Write down the balanced equation for the net cell reaction taking
                  place.   (3)

        8.2.5   The concentration of Ni^{2+}(aq) is now increased.
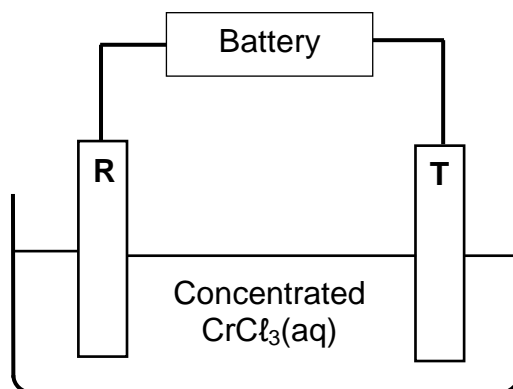
                  Will the reading on the voltmeter INCREASE, DECREASE or
                  REMAIN THE SAME?   (1)
   **[15]**

QUESTION 9 (Start on a new page.)

The diagram below represents a simplified cell used for the electrolysis of CONCENTRATED chromium(III) chloride, $CrC\ell_3$(aq). Electrodes **R** and **T** are made of carbon.

The net cell reaction is: $2CrC\ell_3$(aq) $\rightarrow$ $2Cr$(s) $+$ $3C\ell_2$(g)

9.1　　　Define the term *electrolysis.*　　　(2)

9.2　　　The graph below, NOT drawn to scale, represents the changes in the mass of electrode **T** during electrolysis.
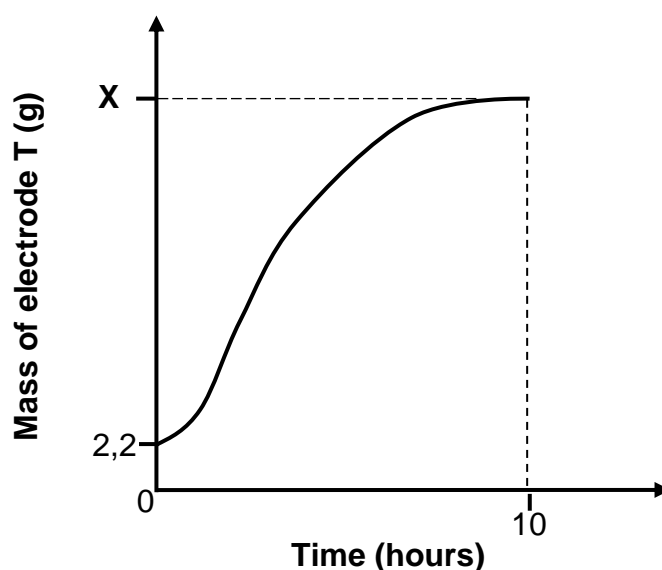
9.2.1　　Write down the half-reaction that takes place at electrode **T**.　　　(2)

A current of 2,5 A passes through the cell for 10 hours.

Calculate the:

9.2.2　　Total charge that flows through the cell during this time　　　(3)

9.2.3　　Value of **X** as shown on the graph　　　(6)

[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*

$n = \dfrac{m}{M}$	$n = \dfrac{N}{N_A}$
$c = \dfrac{n}{V}$ or/*of* $c = \dfrac{m}{MV}$	$n = \dfrac{V}{V_m}$
$\dfrac{c_a V_a}{c_b V_b} = \dfrac{n_a}{n_b}$	pH = -log[H$_3$O$^+$]

$$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14} \text{ at/}by \text{ 298 K}$$

$$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode} / E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$$

or/*of*

$$E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation} / E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$$

or/*of*

$$E^{\theta}_{cell} = E^{\theta}_{oxidising\,agent} - E^{\theta}_{reducing\,agent} / E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$$

$$q = I\Delta t$$

$$n = \frac{Q}{e} \quad \text{or/}of \quad n = \frac{Q}{q_e}$$

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

KEY/*SLEUTEL*

Atomic number
Atoomgetal

Electronegativity
Elektronegatiwiteit →

29
1,9 Cu
63,5

← Symbol
Simbool

Approximate relative atomic mass
Benaderde relatiewe atoommassa

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 101	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
$\mathbf{2H^+ + 2e^- \rightleftharpoons H_2(g)}$	**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

Half-reactions/*Halfreaksies*	E^θ (V)
$Li^+ + e^- \rightleftharpoons Li$	$-3,05$
$K^+ + e^- \rightleftharpoons K$	$-2,93$
$Cs^+ + e^- \rightleftharpoons Cs$	$-2,92$
$Ba^{2+} + 2e^- \rightleftharpoons Ba$	$-2,90$
$Sr^{2+} + 2e^- \rightleftharpoons Sr$	$-2,89$
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	$-2,87$
$Na^+ + e^- \rightleftharpoons Na$	$-2,71$
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	$-2,36$
$A\ell^{3+} + 3e^- \rightleftharpoons A\ell$	$-1,66$
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	$-1,18$
$Cr^{2+} + 2e^- \rightleftharpoons Cr$	$-0,91$
$2H_2O + 2e^- \rightleftharpoons H_2(g) + 2OH^-$	$-0,83$
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	$-0,76$
$Cr^{3+} + 3e^- \rightleftharpoons Cr$	$-0,74$
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	$-0,44$
$Cr^{3+} + e^- \rightleftharpoons Cr^{2+}$	$-0,41$
$Cd^{2+} + 2e^- \rightleftharpoons Cd$	$-0,40$
$Co^{2+} + 2e^- \rightleftharpoons Co$	$-0,28$
$Ni^{2+} + 2e^- \rightleftharpoons Ni$	$-0,27$
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	$-0,14$
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	$-0,13$
$Fe^{3+} + 3e^- \rightleftharpoons Fe$	$-0,06$
$\mathbf{2H^+ + 2e^- \rightleftharpoons H_2(g)}$	**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 oxidising agents/*Toenemende sterkte van oksideermiddels*

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