EXAMINATION	NATIONAL SENIOR CERTIFICATE
GRADE	12
DATE	JUNE 2024
SUBJECT	PHYSICAL SCIENCES
PAPER	2
MARK TOTAL	150
DURATION (HOURS)	3
NUMBER OF PAGES	20

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SOUTH AFRICAN COMPREHENSIVE ASSESSMENT INSTITUTE

SUID-AFRIKAANSE KOMPREHENSIEWE ASSESSERINGSINSTITUUT

INSTRUCTIONS AND INFORMATION

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

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

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

4. Leave **ONE** line between two sub questions, for example between **QUESTION 2.1** and **QUESTION 2.2**.

5. You may use a non-programmable calculator.

6. You may use appropriate mathematical instruments.

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

8. Show **ALL** formulae and substitutions in **ALL** calculations.

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

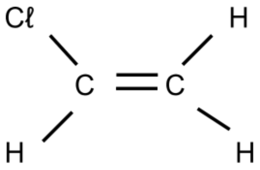
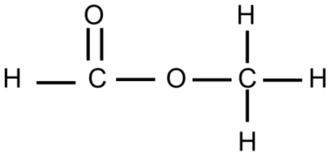
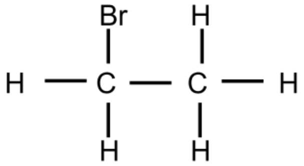
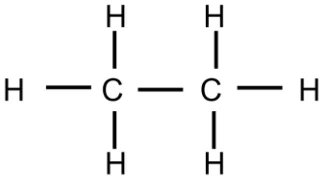
10. Give brief motivations, discussions, et cetera where required.

11. Write neatly and legibly, in **BLUE** ink only.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A−D) next to the question number (1.1−1.10) in the ANSWER BOOK, for example **1.11 D.**

1.1 Which ONE of the following compounds has STRUCTURAL ISOMERS?

A		B	
C		D	

(2)

1.2 If only TWO products are obtained from the cracking of $C_{14}H_{30}$ it could be:

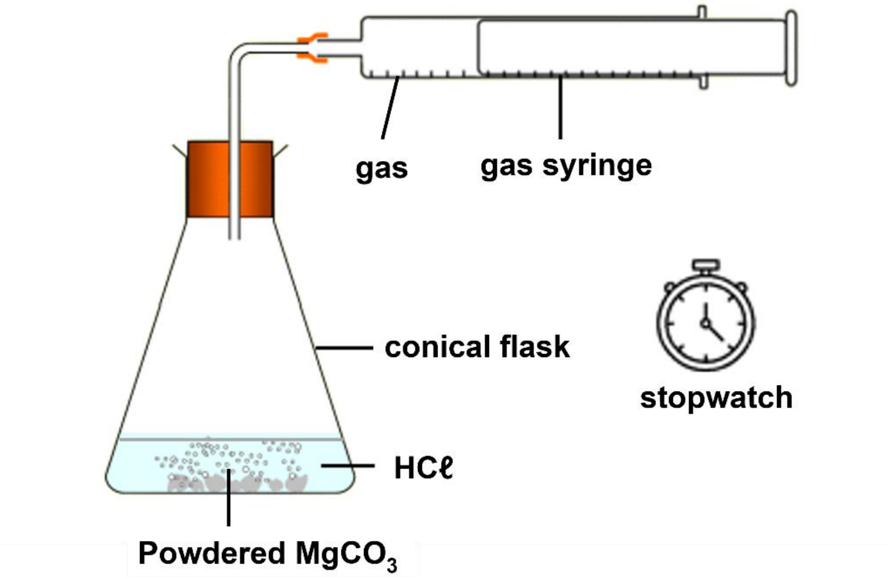
A heptane and heptene
B two heptane molecules
C octane and hexane
D octene and hexene (2)

1.3 The test for determining whether an organic compound is UNSATURATED assumes that:

A The unsaturated compound will react slowly with bromine.
B The unsaturated compound will react quickly with bromine.
C The unsaturated compound will undergo substitution with bromine.
D The colour of the solution will remain brown during the reaction. (2)

1.4 Powdered magnesium carbonate ($MgCO_3$) reacts with EXCESS hydrochloric acid ($HC\ell$) using the apparatus shown.

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



The gas is collected in the syringe in 36 s.
The experiment is repeated using $MgCO_3$ chips and the mass of $MgCO_3$ is the same in both experiments. How long does it take to collect the gas in this experiment?

A 9 s
B 18 s
C 36 s
D 72 s (2)

1.5 10 g of magnesium (Mg) react with 10 g of hydrochloric acid ($HC\ell$) according to the following balanced equation:

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

The mass of $MgC\ell_2$ produced is:

A 13,05 g
B 39,58 g
C 26,03 g
D 0,27 g (2)

1.6 The following hypothetical reaction reaches equilibrium in a closed container at a certain temperature.

$$\mathbf{2\,X\,(s) + 3\,Y_2\,(g) \rightleftharpoons 2\,XY_3\,(g) \qquad \Delta H < 0}$$

Which ONE of the following conditions of pressure and temperature will DECREASE the yield of XY_3 (g)?

	Pressure	**Temperature**
A	low	Low
B	high	High
C	low	High
D	high	Low

(2)

1.7 Consider the equation below.

$$\mathbf{H_2PO_4^- (aq) + H_2O (aq) \rightleftharpoons H_3O^+ (aq) + HPO_4^{2-} (aq)}$$

Which ONE of the following is a conjugate acid-base pair?

A $H_2PO_4^-$ (aq) and HPO_4^{2-} (aq)
B HPO_4^{2-} (aq) and H_3O^+ (aq)
C H_2O (aq) and HPO_4^{2-} (aq)
D $H_2PO_4^-$ (aq) and H_2O (aq) (2)

1.8 Which ONE of the following solutions will have a pH less than 7?

A CH_3COONa (aq)
B Na_2SO_4 (aq)
C $KC\ell$ (aq)
D $NH_4C\ell$ (aq) (2)

1.9 Consider the net ionic reaction of a nickel-lead (Ni-Pb) galvanic cell.

$$\mathbf{Ni (s) + Pb^{2+} (aq) \rightleftharpoons Ni^{2+} (aq) + Pb (s)}$$

Which ONE of the following correctly describes the movement of electrons in the external circuit and the ion movement in the electrolyte?

	External circuit	**Ion movement in electrolyte**
A	Electrons move from Ni to Pb	Pb^{2+} (aq) move away from Pb (s)
B	Electrons move from Ni to Pb	Pb^{2+} (aq) move towards Pb (s)
C	Electrons move from Pb to Ni	Ni^{2+} (aq) move away from Ni (s)
D	Electrons move from Pb to Ni	Ni^{2+} (aq) move towards Ni (s)

(2)

1.10 Which ONE of the following is a NON-SPONTANEOUS redox reaction?

A Copper (Cu) turnings in a silver nitrate ($AgNO_3$) solution.
B Copper (Cu) turnings in a cobalt (II) chloride ($CoCl_2$) solution.
C Magnesium (Mg) ribbon in a copper (II) nitrate ($Cu(NO_3)_2$) solution.
D Iron (Fe) nail in a copper (II) sulphate ($CuSO_4$) solution. (2)

[20]

QUESTION 2 [START ON A NEW PAGE]

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

A	2-methylpentane	**B**	3-methylpentane
C	1-chlorobutane	**D**	1-chloro-2-methylpropane
E	Butanoic acid	**F**	Ethyl ethanoate

2.1 Are compounds **A** and **B** SATURATED or UNSATURATED? (1)

2.2 Write down the:

2.2.1 HOMOLOGOUS series to which compound **D** belongs. (1)

2.2.2 Name of the FUNCTIONAL GROUP of compound **E**. (1)

2.2.3 NAMES of the two REACTANTS used to prepare compound **F**. (2)

2.3 Consider compounds **D**, **E** and **F**:

2.3.1 Draw the STRUCTURAL formula of compound **E**. (2)

2.3.2 Give the CONDENSED structural formula of compound **D**. (2)

2.3.3 Give the MOLECULAR formula of compound **F**. (2)

2.4 Define the term *structural isomer*. (2)

2.5 Identify the specific TYPE of STRUCTURAL ISOMER illustrated by:

2.5.1 Compounds **A** and **B**. (1)

2.5.2 Compounds **E** and **F**. (1)

2.6 Draw the STRUCTURAL formula of compound **C**. (2)

[17]

QUESTION 3 [START ON A NEW PAGE]

3.1 A learner prepares samples of **pent-2-ene** and **pentan-2-ol** in the laboratory. She manages to lose the labels on the sample bottles. Both compounds are colourless liquids. In order to identify each sample, she determines the boiling point of each under the same conditions. Her results are in the table below.

Sample	**Boiling point (°C)**
A	119
B	37

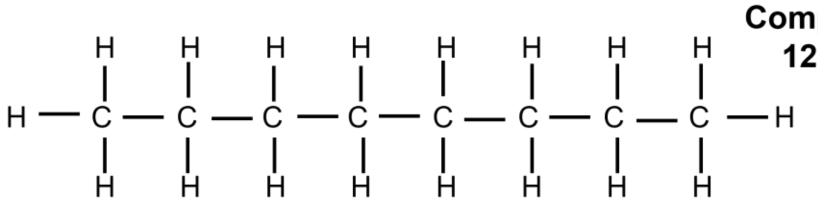
3.1.1 What is the DEPENDENT variable in this investigation? (1)

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

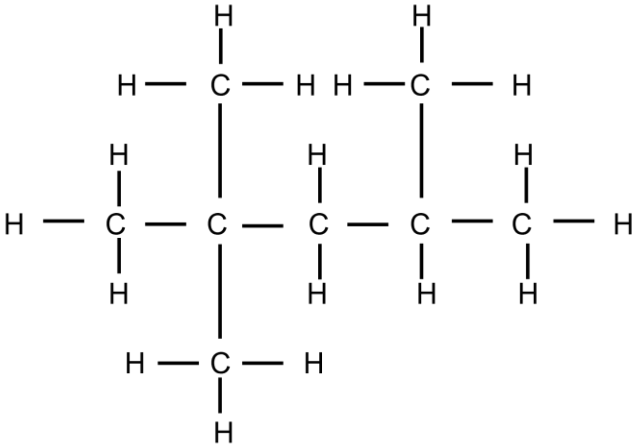
3.1.3 Which sample, **A** or **B**, is pentan-2-ol? (1)

3.1.4 Explain the answer to QUESTION 3.1.3 by referring to the strengths of intermolecular forces present in EACH of these compounds. (4)

3.2 Consider compounds **A** and **B** below.



Compound A
125,6 °C



Compound B
99 °C

3.2.1 Write down the IUPAC name of compound **B**? (2)

3.2.2 What specific TYPE of isomer is compound **B**? (1)

3.3 Consider the following organic compounds:

2,2-dimethylbutane	**pentan-1-ol**	**ethyl propanoate**

3.3.1 Define *vapour pressure*. (2)

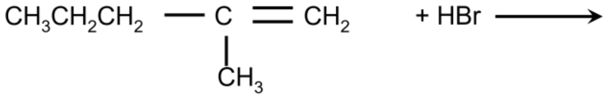
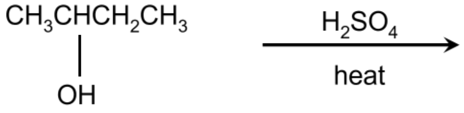
3.3.2 Which compound will have the LOWEST vapour pressure? (1)

3.3.3 By referring to the strength of intermolecular forces present, explain the difference in vapour pressure between **2,2-dimethylbutane** and **ethyl propanoate**. (4)

[18]

QUESTION 4 [START ON A NEW PAGE]

Organic compounds undergo different reactions to produce a variety of organic compounds. Consider the incomplete reaction equations below and answer the questions that follow.

I	$CH_3 - CH_2 - CH = CH_2 + H_2 \longrightarrow$
II	 $CH_3CH_2CH_2 - \underset{\underset{CH_3}{\vert}}{C} = CH_2 \quad + HBr \longrightarrow$
III	 $CH_3\underset{\underset{OH}{\vert}}{CH}CH_2CH_3 \quad \xrightarrow[\text{heat}]{H_2SO_4}$

4.1 Consider reaction **I**.

4.1.1 This reaction only takes place in the presence of a catalyst. Write down the CHEMICAL FORMULA of the catalyst. (1)

4.1.2 Write down the IUPAC name of the product that is formed. (2)

4.1.3 Using MOLECULAR formulae, write down the balanced equation for the complete combustion of the organic product in QUESTION 4.1.2. (3)

4.2 Both reactions **I** and **II** are addition reactions.

4.2.1 Name the SPECIFIC type of addition reaction that is represented by each reaction. (2)

4.2.2 Write down the MOLECULAR formula of the product that is formed in reaction II. (1)

4.3 Consider reaction **III**.

4.3.1 Name the GENERAL type of reaction represented by reaction **III**. (1)

4.3.2 To which homologous series does the product formed in reaction **III** belong? (1)

4.3.3 Using STRUCTURAL formulae, write down the balanced equation for reaction **III**. (3)

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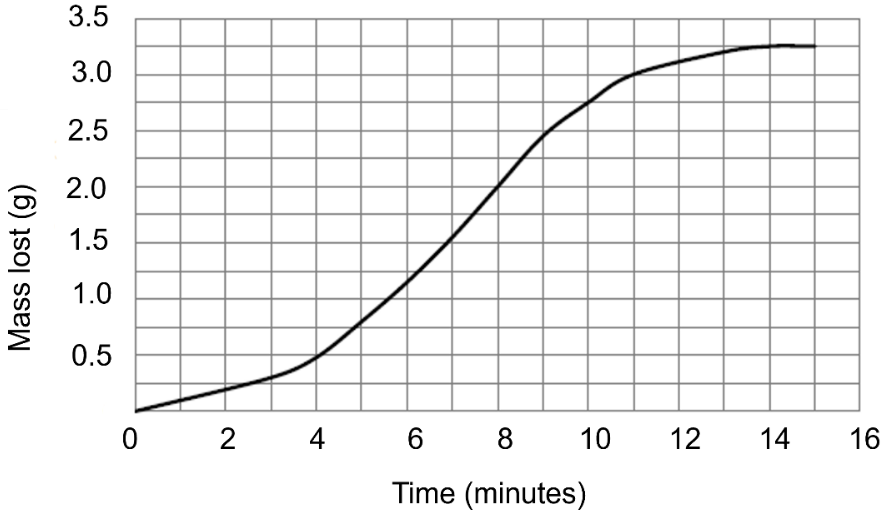
QUESTION 5 [START ON A NEW PAGE]

Large lumps of calcium carbonate ($CaCO_3$) with a total mass of 12 g are placed in an open flask. 200 cm^3 hydrochloric acid ($HC\ell$) of concentration 3 $mol.dm^{-3}$ is added to completely cover the lumps. The mass of the flask is determined every two minutes. The balanced chemical equation for the reaction taking place in the flask is:

$$CaCO_3 (s) + 2 HC\ell (aq) \rightarrow CaC\ell_2 (aq) + CO_2 (g) + H_2O (\ell)$$

A graph of the results is shown below.

Graph of mass lost versus time for the reaction



5.1 Calculate the number of moles of $CaCO_3$ in a 12 g sample. (3)

5.2 Which reactant is in EXCESS? Show all calculations. (4)

5.3 How does the rate of reaction at 4 minutes compare to the rate of reaction at 8 minutes? Choose GREATER THAN, EQUAL TO or SMALLER THAN. (1)

5.4 Use the Collision Theory to fully explain the answer to QUESTION 5.3. (3)

5.5 What is the final mass of CO_2 produced. (1)

5.6 Determine the percentage yield of CO_2. (5)

5.7 This reaction is now repeated using 12 g of POWDERED $CaCO_3$ and the $HC\ell$ unchanged. What effect (if any) will this have on:

5.7.1 The gradient of the graph. (1)

5.7.2 The final mass of CO_2 produced. (1)

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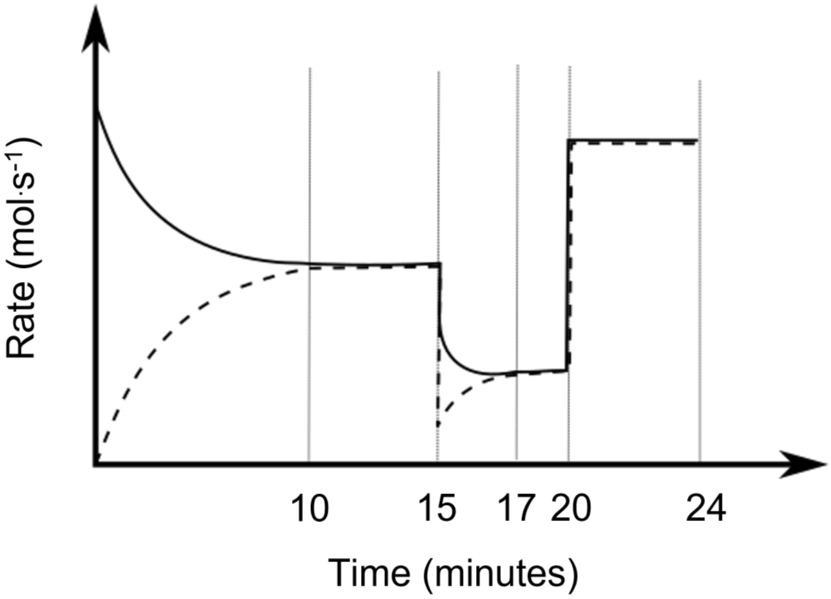
QUESTION 6 [START ON A NEW PAGE]

6.1 Nitrogen and oxygen gases react in a sealed container according to the following balanced equation:

$$N_2\,(g) + O_2\,(g) \rightleftharpoons 2\,NO\,(g)$$

The reaction rate versus time graph below represents different changes made to the equilibrium mixture.



6.1.1 Define *reversible reaction*. (2)

6.1.2 Write down the balanced equation for the reaction represented by the broken line on the graph. (1)

6.1.3 What do the parallel lines between 10 and 15 minutes indicate? Explain the answer. (2)

6.1.4 At 15 minutes a temperature change takes place. Was the temperature INCREASED or DECREASED? (1)

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

6.1.6 Explain the answer to QUESTION 6.1.5. (2)

6.1.7 What effect does the temperature change in QUESTION 6.1.4 have on the value of Kc? Choose from INCREASES, DECREASES or NO EFFECT. Explain the answer. (2)

6.1.8 What change was made to the equilibrium mixture at time 20 minutes? (1)

6.1.9 Use the graph to explain the answer to QUESTION 6.1.8. (2)

6.2 The balanced equation below represents an equilibrium reaction in a sealed,1 dm^3 container.

$$\mathbf{NO_2\ (g) + NO\ (g) \rightleftharpoons N_2O\ (g) + O_2\ (g) \qquad \Delta H > 0}$$

Equilibrium was reached at a certain temperature and the value of Kc was 3,93. The concentration of each reactant and product in the container at equilibrium was:

$[NO_2] = 0,06\ mol\cdot dm^{-3}$	$[NO] = 0,29\ mol\cdot dm^{-3}$
$[N_2O] = 0,18\ mol\cdot dm^{-3}$	$[O_2] = 0,38\ mol\cdot dm^{-3}$

One of the conditions affecting the equilibrium is changed and a new equilibrium is established. At the new equilibrium, the concentration of the NO_2 is $0,12\ mol\cdot dm^{-3.}$

6.2.1 Calculate the equilibrium constant, Kc, at the new equilibrium. (5)

6.2.2 Was the FORWARD or REVERSE reaction favoured? (1)

6.2.3 Give a reason for the answer to QUESTION 6.2.2. (1)

[21]

QUESTION 7 [START ON A NEW PAGE]

7.1 A listed ingredient in some soft drinks is phosphoric acid (H_3PO_4). It is a weak, polyprotic acid with a K_a value of 7,3 x 10^{-4} at 25 ºC. It is therefore safer to have in soft drinks than hydrochloric acid (HCℓ).

7.1.1 Define an *acid* according to the Lowry-Bronsted theory. (2)

7.1.2 Explain why H_3PO_4 is described as *polyprotic*. (1)

7.2 A learner needs to determine the concentration of a phosphoric acid (H_3PO_4) solution. She decides to titrate the H_3PO_4 against a standard solution of sodium hydroxide (NaOH). The balanced chemical equation for the reaction is given below:

$$3\ NaOH\ (aq) + H_3PO_4\ (aq) \rightarrow Na_3PO_4\ (aq) + 3\ H_2O\ (\ell)$$

7.2.1 Calculate the mass of NaOH needed to make up 500 cm^3 of a 0,22 mol·dm^{-3} NaOH solution. (3)

7.2.2 During the titration she found that 15 cm^3 of a 0,22 mol·dm^{-3} NaOH solution neutralises 20 cm^3 of the H_3PO_4 solution. Calculate the concentration of the H_3PO_4. (5)

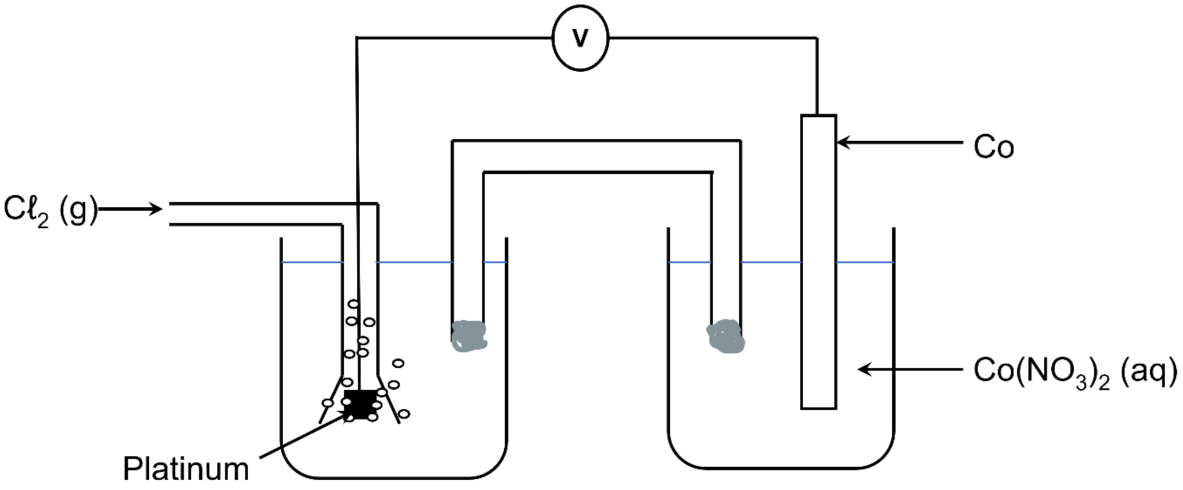
7.2.3 Will the pH of the solution at the end point be GREATER THAN 7, SMALLER THAN 7 or EQUAL TO 7? (1)

7.2.4 Explain the answer to QUESTION 7.2.3 with the aid of a balanced chemical equation. (3)

[15]

QUESTION 8 [START ON A NEW PAGE]

An electrochemical cell consisting of a cobalt (Co) half-cell, a salt bridge with a potassium nitrate (KNO_3) solution and a chlorine ($C\ell_2$) half-cell is set up under standard conditions.



8.1 State the energy conversion that takes place in this cell. (2)

8.2 What is the concentration of the electrolyte in the cobalt half-cell. (1)

8.3 A suitable electrolyte for the chlorine half-cell is $HC\ell$. Define *electrolyte*. (2)

8.4 Write down the NAME or FORMULA of the reducing agent in this cell. (1)

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

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

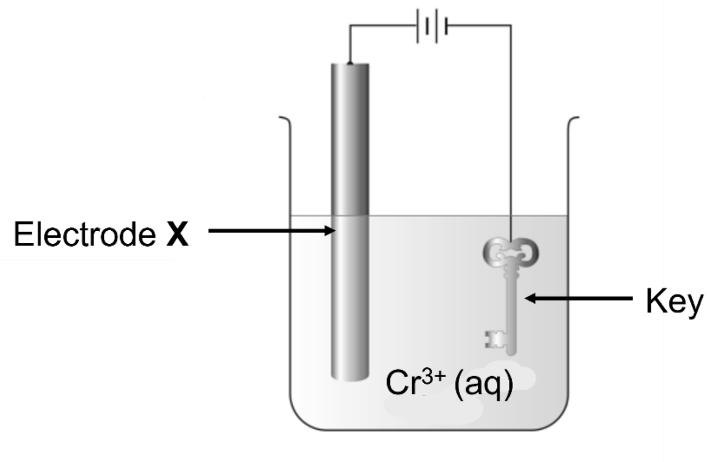
8.7 Calculate the initial emf of this cell. (4)

8.8 After the cell has been assembled, a higher emf is required. A learner suggests that this can be obtained by increasing the concentration of $Co(NO_3)_2$.
Use equilibrium principles to determine whether this suggestion is correct. (3)

[18]

QUESTION 9 **[START ON A NEW PAGE]**

The diagram below represents a cell used to electroplate a key with chromium (Cr).



9.1 What metal is electrode **X** made from? (1)

9.2 Refer to the relative strengths of oxidising agents to explain why chromium will be the predominant substance formed at the key. (3)

9.3 A constant current is run for 8 hours during the electroplating process. If the amount (in mol) of electrons transferred to the key during this time is 0,22 mol, calculate the mass of chromium deposited onto the key. (4)

[8]

GRAND TOTAL: 150

DATA SHEET FOR PHYSICAL SCIENCES
INLIGTINGSBLAD VIR FISIESE WETENSKAPPE
PAPER 2 (CHEMISTRY)
VRAESTEL 2 (CHEMIE)

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

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

TABLE 2: FORMULAE / *TABEL 2: FORMULE*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at 298K	
$E^{\theta}_{cell/sel} = E^{\theta}_{cathode/katode} - E^{\theta}_{anode}$ Or/ of $E^{\theta}_{cell/sel} = E^{\theta}_{reduction/reduksie} - E^{\theta}_{oxidaton/oksidasie}$ Or/ of $E^{\theta}_{cell/sel} = E^{\theta}_{oxidising\ agent/\ oksideermiddel} - E^{\theta}_{reducing\ agent/\ reduseermiddel}$	

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)
2,1 1 H 1																	2 He 4
1,0 3 Li 7	1,5 4 Be 9											2.0 5 B 11	2.5 6 C 12	3,0 7 N 14	3,5 8 O 16	4.0 9 F 19	10 Ne 20
0,9 11 Na 23	1,2 12 Mg 24											1.5 13 Aℓ 27	1.8 14 Si 28	2,1 15 P 31	2,5 16 S 32	3,0 17 Cℓ 35,5	18 Ar 40
0,8 19 K 39	1,0 20 Ca 40	1,3 21 Sc 45	1.5 22 Ti 48	1.6 23 V 51	1,6 24 Cr 52	1.5 25 Mn 55	1.8 26 Fe 56	1.8 27 Co 59	1.8 28 Ni 59	1.9 29 Cu 63,5	1.6 30 Zn 65	1.6 31 Ga 70	1.8 32 Ge 73	2,0 33 As 75	2.4 34 Se 79	2.8 35 Br 80	36 Kr 84
0,8 37 Rb 86	1,0 38 Sr 88	1,2 39 Y 89	1.4 40 Zr 91	41 Nb 92	1,8 42 Mo 96	1.9 43 Tc	2,2 44 Ru 101	2,2 45 Rh 103	2,2 46 Pd 106	1.9 47 Ag 108	1.7 48 Cd 112	1.7 49 In 115	1.8 50 Sn 119	1.9 51 Sb 122	2,1 52 Te 128	2.5 53 I 127	54 Xe 131
0,7 55 Cs 133	0,9 56 Ba 137	57 La 139	1.6 72 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	1.8 81 Tℓ 204	1.8 82 Pb 207	1.9 83 Bi 209	2,0 84 Po	2.5 85 At	86 Rn
0,7 87 Fr	0,9 88 Ra 226	89 Ac															

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 oxidising ability/*Toenemende oksiderende vermoë*

Half-reactions/*Half-reaksies*	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

Increasing reducing ability/*Toenemende reduserende vermoë*

TABLE 4B: STANDARD REDUCTION POTENTIALS/*TABEL 4B: STANDAARD REDUKSIEPOTENSIALE*

Increasing oxidising ability/*Toenemende oksiderende vermoë*

Increasing reducing ability/*Toenemende reduserende vermoë*

Half-reactions/*Half-reaksies*			**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
$Pt^{2+} + 2\,e^-$	$\rightleftharpoons$	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
$H_2O_2 + 2H^+ + 2\,e^-$	$\rightleftharpoons$	$2H_2O$	+1,77
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 2,87