basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL
SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

NOVEMBER 2010

MARKS: 150

TIME: 3 hours

This question paper consists of 15 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. Answer ALL the questions in the ANSWER BOOK.

3. This question paper consists of TWO sections:

   SECTION A (25)
   SECTION B (125)

4. You may use a non-programmable calculator.

5. You may use appropriate mathematical instruments.

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

7. Data sheets and a periodic table are attached for your use.

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

SECTION A

QUESTION 1: ONE-WORD ITEMS

Give ONE word/term for each of the following descriptions. Write only the word/term next to the question number (1.1 – 1.5) in the ANSWER BOOK.

1.1 The homologous series to which H – C Ξ C – H belongs (1)

1.2 The electrode in a galvanic cell at which reduction takes place (1)

1.3 The type of chemical reaction that releases energy (1)

1.4 The type of electrochemical cell used in industry to produce elements such as chlorine and aluminium (1)

1.5 The process by which an increase in the concentration of primary nutrients in a river leads to algal bloom (1)

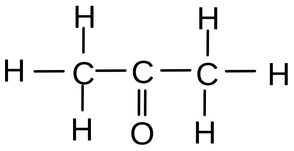
[5]

QUESTION 2: 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 (2.1 – 2.10) in the ANSWER BOOK.

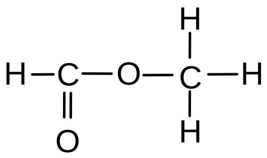
2.1 Which ONE of the following compounds represents a ketone?

A



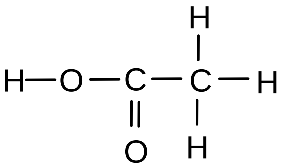
$H-\overset{H}{\underset{H}{C}}-\underset{\overset{\|}{O}}{C}-\overset{H}{\underset{H}{C}}-H$

B



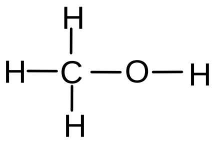
$H-\underset{\overset{\|}{O}}{C}-O-\overset{H}{\underset{H}{C}}-H$

C



$H-O-\underset{\overset{\|}{O}}{C}-\overset{H}{\underset{H}{C}}-H$

D



$H-\overset{H}{\underset{H}{C}}-O-H$

(2)

2.2 Consider the compound with molecular formula C_4H_{10}. How many structural isomers does this compound have?

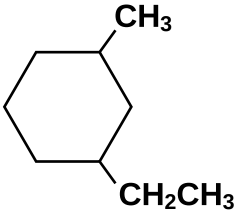
A 1
B 2
C 3
D 4

(2)

2.3 Which ONE of the following pairs of reactants can be used to prepare the ester ethyl butanoate in the laboratory?

A Ethanal and butanol
B Ethanoic acid and butanol
C Ethanol and butanoic acid
D Ethanal and butanoic acid (2)

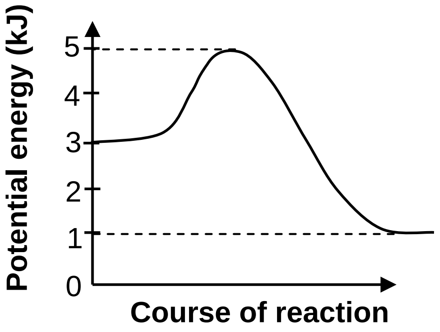
2.4 A cyclic hydrocarbon is represented below.



Which ONE of the following is the correct IUPAC name of this compound?

A 3-methyl-1-ethylcyclohexane
B 1-ethyl-5-methylcyclohexane
C 1-methyl-5-ethylcyclohexane
D 1-ethyl-3-methylcyclohexane (2)

2.5 The graph below represents the relationship between potential energy and course of reaction for a certain chemical reaction.



The activation energy for the forward reaction is …

A 1 kJ.
B 2 kJ.
C 3 kJ.
D 4 kJ. (2)

2.6 The reaction represented by the equation below reaches equilibrium.

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

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

A Add a catalyst.

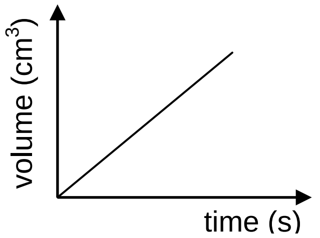
B Place the reaction mixture in a container with hot water.

C Add a few drops of concentrated hydrochloric acid to the reaction mixture.

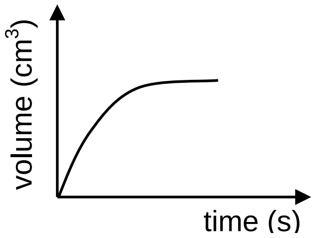
D Add water to the reaction mixture. (2)

2.7 One of the products formed in a chemical reaction is a gas. Which ONE of the following graphs of volume versus time best represents the formation of this gas until the reactants are used up?

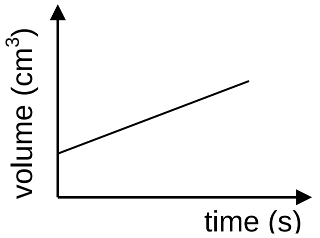
A



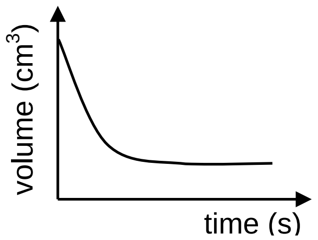
B



C



D



(2)

2.8 Which ONE of the following statements regarding the anode of a standard galvanic cell in operation is correct?

A The anode accepts electrons.

B The mass of the anode decreases.

C The concentration of the electrolyte in the half-cell containing the anode initially decreases.

D The anode is the positive terminal of the cell. (2)

2.9 Consider the reaction represented by the following equation:

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

Which ONE of the following represents the oxidising agent in the above reaction?

A Ag^+

B Ag

C Cu

D Cu^{2+} (2)

2.10 A membrane cell is used for the electrolysis of brine (saturated solution of salt and water). One function of the membrane in this cell is to allow … to pass through it.

A molecules

B anions

C cations

D both anions and cations (2)

[20]

TOTAL SECTION A: 25

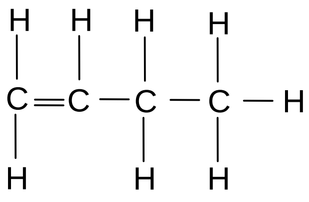
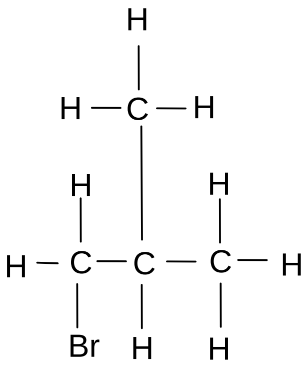
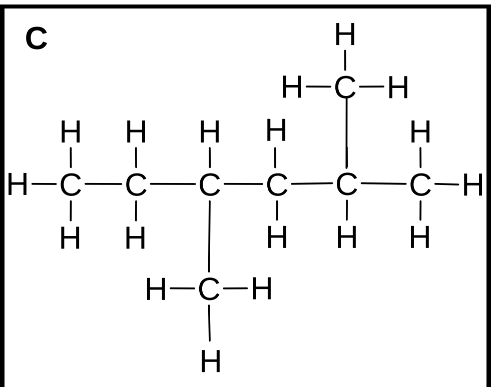
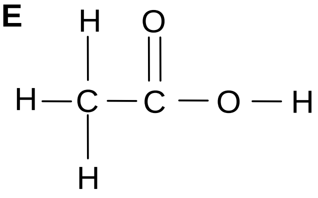
SECTION B

INSTRUCTIONS

1. Start each question on a NEW page.
2. Leave one line between two subquestions, for example between QUESTION 3.1 and QUESTION 3.2.
3. Show the formulae and substitutions in ALL calculations.
4. Round off ALL numerical answers to TWO decimal places.

QUESTION 3 (Start on a new page.)

The chemical properties of organic compounds are determined by their functional groups. The letters **A** to **F** in the table below represent six organic compounds.

A 	**B** 	**C** 
D Methanal	**E** 	**F** Methyl methanoate

3.1 Write down the LETTER that represents the following:

3.1.1 An alkene (1)

3.1.2 An aldehyde (1)

3.2 Write down the IUPAC name of the following:

3.2.1 Compound **B** (2)

3.2.2 Compound **C** (2)

3.3 Write down the structural formula of compound **D**. (2)

3.4 Write down the IUPAC name of the carboxylic acid shown in the table. (2)

3.5 Write down the structural formula of compound **F**. (2)

[12]

QUESTION 4 (Start on a new page.)

Five alcohols represented by the letters **A** – **E** are listed in the table below.

A	Methanol	**B**	Ethanol
C	Propan-1-ol	**D**	Butan-2-ol
E	2-methylpropan-2-ol		

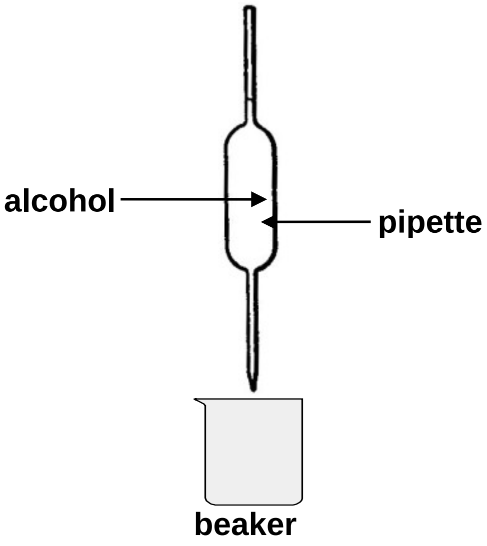
4.1 Which ONE of the above alcohols is a SECONDARY alcohol? Write down only the LETTER that represents the alcohol. (1)

4.2 The letter **E** represents 2-methylpropan-2-ol. For this alcohol, write down the following:

4.2.1 Its structural formula (2)

4.2.2 The LETTER in the table that represents one of its structural isomers (1)

4.3 Viscosity is a measure of a fluid's resistance to flow. Learners conduct an investigation to compare the viscosities of the first three alcohols (**A – C**) in the table above. They use the apparatus shown below.



The learners use the stopwatch to measure the time it takes a FIXED VOLUME of each of the alcohols to flow from the pipette. They record this flow time, which is an indication of the viscosity of each alcohol, as given in the table below.

	Alcohol	Flow time (s)
A	Methanol	4,0
B	Ethanol	7,9
C	Propan-1-ol	14,3

4.3.1 Formulate an investigative question for this investigation. (2)

4.3.2 Which ONE of the alcohols (**A**, **B**, or **C**) has the highest viscosity? Use the data in the table to give a reason for the answer. (2)

4.3.3 Refer to the intermolecular forces of the three alcohols (**A**, **B** and **C**) to explain the trend in viscosities as shown in the table. (2)

4.3.4 Lubricants reduce friction. Which one of alcohols, **A**, **B** or **C**, will be the best lubricant? (1)

4.4 Which ONE of 2-methylpropan-2-ol and butan-2-ol has the higher viscosity? (1)

4.5 Refer to intermolecular forces to explain the answer to QUESTION 4.4. (2)
[14]

QUESTION 5 (Start on a new page.)

Prop-1-ene is a flammable alkene.

5.1 Why is prop-1-ene considered to be a dangerous compound? (1)

Through addition reactions, prop-1-ene can be converted to other compounds, such as alkanes and alcohols.

5.2 Which part of the structure of an alkene allows it to undergo addition reactions? (1)

5.3 In one type of addition reaction, prop-1-ene can be converted to an alcohol.

5.3.1 Use structural formulae to write a balanced equation for the formation of the alcohol during this addition reaction. (4)

5.3.2 Name the type of addition reaction that takes place. (1)

5.3.3 Write down the name or formula of the catalyst used in this reaction. (1)

5.4 Use molecular formulae to write down a balanced chemical equation for the complete combustion of propane. (3)

Prop-1-ene can be produced from an alcohol by an elimination reaction.

5.5 Use structural formulae to write a balanced chemical equation for the formation of prop-1-ene from a PRIMARY alcohol. (4)

5.6 Name the type of elimination reaction that takes place. (1)
[16]

QUESTION 6 (Start on a new page.)

6.1 The collision theory explains why chemical reactions occur and why they take place at different rates.

Some of the terms used in the collision theory and reaction rate are given below.

surface area;	catalyst;	effective collision;	activated complex;
concentration;	temperature;	heat of reaction;	activation energy

Give ONE term for each of the following descriptions by choosing a term from the list above. Write down only the term next to the question number (6.1.1 – 6.1.6) in the ANSWER BOOK.

6.1.1 A chemical substance that speeds up the rate of a chemical reaction by lowering the net activation energy (1)

6.1.2 A collision in which the reacting particles have sufficient kinetic energy and the correct orientation (1)

6.1.3 The factor responsible for increasing the rate of a reaction when a solid is broken up into smaller pieces (1)

6.1.4 The temporary unstable state that is formed during the course of a chemical reaction (1)

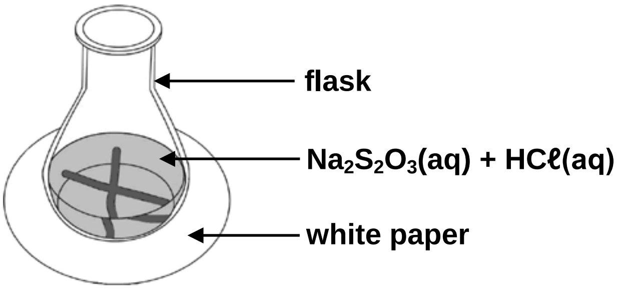
6.1.5 A measure of the average kinetic energy of the particles in a gas (1)

6.1.6 The net amount of energy released or absorbed during a chemical reaction (1)

6.2 Learners use hydrochloric acid and a sodium thiosulphate ($Na_2S_2O_3$) solution to investigate the relationship between rate of reaction and temperature. The reaction that takes place is represented by the following equation:

$$Na_2S_2O_3(aq) + 2HC\ell(aq) \rightarrow 2NaC\ell(aq) + S(s) + H_2O(\ell) + SO_2(g)$$

They add 5 cm^3 dilute hydrochloric acid solution to 50 cm^3 sodium thiosulphate solution in a flask placed over a cross drawn on a sheet of white paper, as shown in the diagram below. The temperature of the mixture is 30 °C.



They measure the time it takes for the cross to become invisible. The experiment is repeated with the temperature of the mixture at 40 °C, 50 °C and 60 °C respectively.

6.2.1 Write down a possible hypothesis for this investigation. (2)

6.2.2 Write down the NAME or FORMULA of the product that requires the need to work in a well-ventilated room. (1)

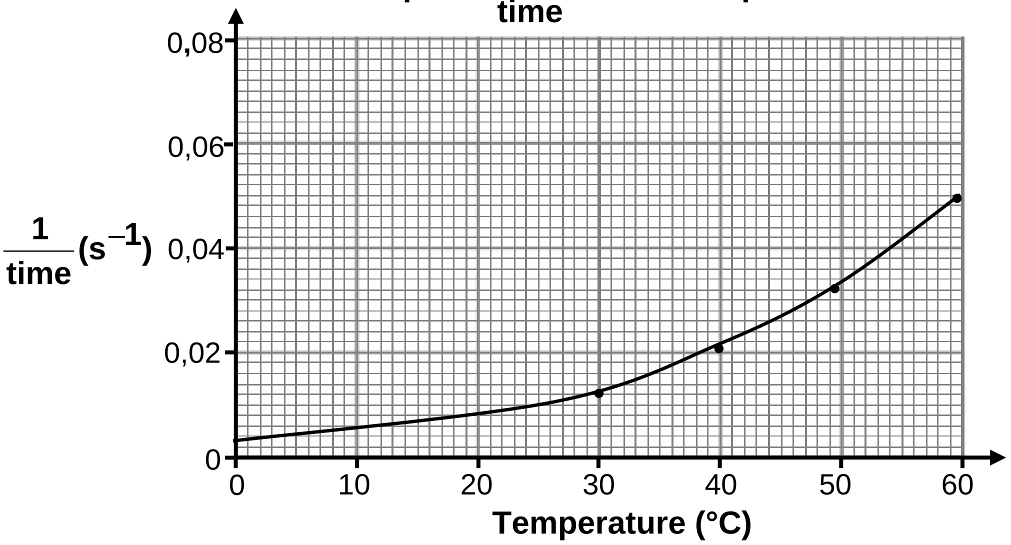
6.2.3 Apart from the volume of the reactants, state ONE other variable that must be kept constant during this investigation. (1)

6.2.4 Write down the NAME or FORMULA of the product that causes the cross to become invisible. (1)

6.2.5 Why is it advisable that the same learner observes the time that it takes for the cross to become invisible? (1)

The graph shown below is obtained from the results.

Graph of $\frac{1}{\text{time}}$ versus temperature

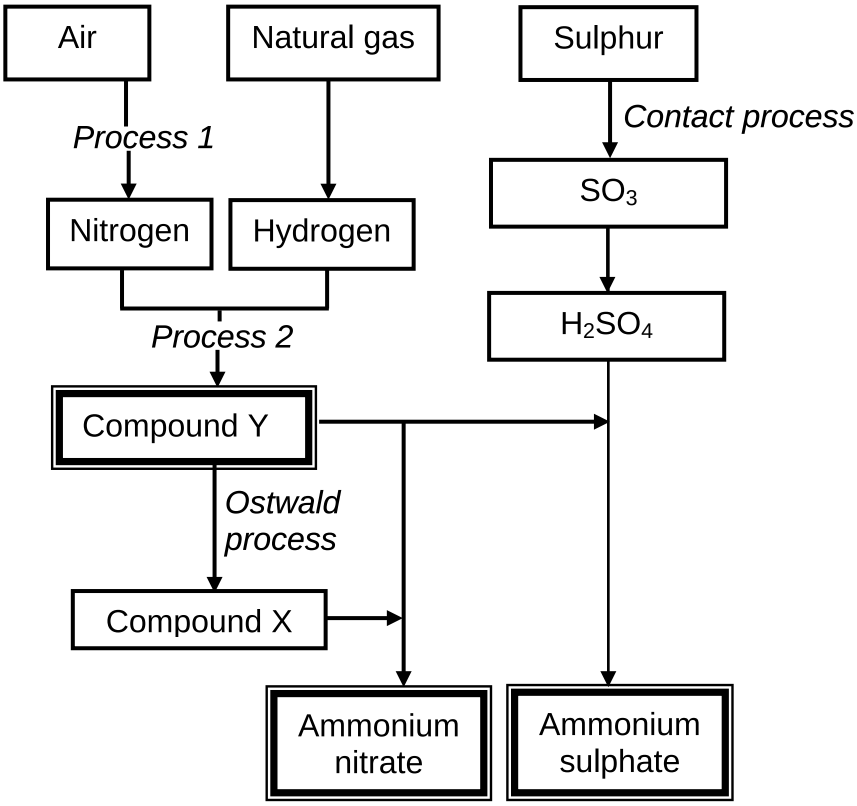


6.2.6 What is represented by $\frac{1}{\text{time}}$ on the vertical axis? (1)

6.2.7 What conclusion can be drawn from the results obtained? (2)
[15]

QUESTION 7 (Start on a new page.)

Ammonia, **ammonium nitrate** and **ammonium sulphate** are three important nitrogen-containing fertilisers. The flow diagram below shows how these fertilisers are produced in industry.



7.1 Use the information in the flow diagram above and write down the following:

7.1.1 Name of Process 1 (1)

7.1.2 Balanced equation for Process 2 (3)

7.1.3 NAME or FORMULA of compound X (1)

7.1.4 Balanced equation for the preparation of ammonium sulphate using sulphuric acid and compound Y (3)

7.1.5 NAME or SYMBOL of the primary nutrient in ammonium sulphate (1)

7.2 Write down ONE positive impact of fertilisers on humans. (2)

7.3 Write down TWO negative impacts of the use of ammonium nitrate, as fertiliser, on humans. (4)

The reaction below represents the catalysed step in the contact process:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H < 0$$

7.4 The reaction takes place in a closed container and reaches equilibrium at 427 °C. How will a HIGHER temperature affect each of the following? Write down only INCREASES, DECREASES or REMAINS THE SAME.

7.4.1 The rate of production of $SO_3(g)$ (2)

7.4.2 The yield of $SO_3(g)$ (2)

7.5 The reaction is investigated on a small scale in the laboratory. Initially 4 mol of $SO_2(g)$ and an unknown mass, x, of $O_2(g)$ are sealed in a 2 dm^3 flask and allowed to reach equilibrium at a certain temperature.

At equilibrium it is found that the concentration of $SO_3(g)$ present in the flask is 1,5 $mol \cdot dm^{-3}$.

Calculate the mass of $O_2(g)$ initially present in the flask if the equilibrium constant (K_c) at this temperature is 4,5. (9)

[28]

QUESTION 8 (Start on a new page.)

The cell notation of a standard galvanic (voltaic) cell containing an unknown metal electrode **X** is shown below.

$$X(s) \mid X^{3+}(1\ mol \cdot dm^{-3}) \parallel Pb^{2+}(1\ mol \cdot dm^{-3}) \mid Pb(s)$$

8.1 Name the component of the cell represented by the double vertical lines (||) in the above cell notation. (1)

8.2 State the TWO standard conditions that are applicable to the $Pb^{2+}|Pb$ half-cell. (2)

8.3 Identify the oxidising agent in the above cell. (1)

8.4 The initial reading on a voltmeter connected across the electrodes of the above cell is 1,53 V. Identify metal **X** by calculating the standard reduction potential of the unknown metal **X**. (5)

8.5 Write down the balanced equation for the net (overall) reaction taking place in this cell. Omit the spectator ions. (3)

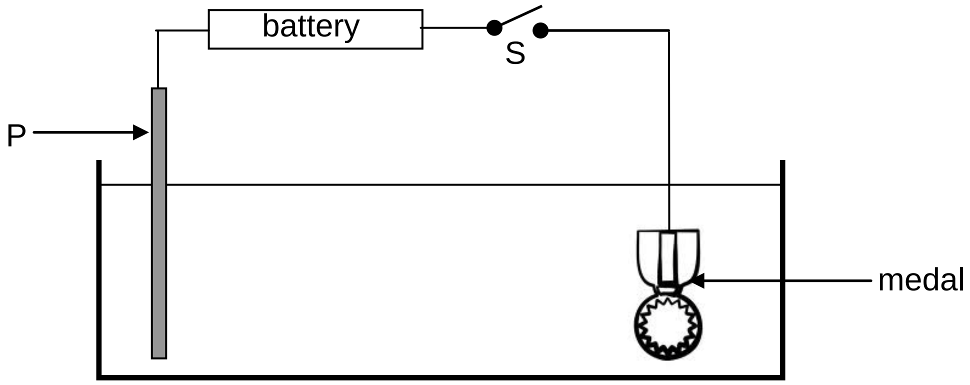
8.6 How will the initial voltmeter reading be affected if the concentration of the electrolyte in the $X(s)|X^{3+}(aq)$ half-cell is increased? Write down only INCREASES, DECREASES or REMAINS THE SAME. (2)

8.7 Write down the value of the reading on the voltmeter when the cell reaction has reached equilibrium. (2)

[16]

QUESTION 9 (Start on a new page.)

The diagram below represents a cell that can be used to electroplate a tin medal with a thin layer of silver to improve its appearance.



9.1 Which one of **P** or the **MEDAL** is the anode in this cell? (1)

9.2 Write down the following:

9.2.1 NAME or SYMBOL of the element of which electrode **P** is composed (1)

9.2.2 NAME or FORMULA of the electrolyte that has to be used to achieve the desired results (1)

9.3 Switch **S** is now closed. Write down the visible changes that will occur at the following:

9.3.1 Electrode **P** (1)

9.3.2 The medal (1)

9.4 Write down the equation for the half-reaction to support the answer to QUESTION 9.3.2. (2)

9.5 How will the concentration of the electrolyte change during the electroplating process? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

9.6 You want to coat the medal with copper instead of silver. State TWO changes that you will make to the above cell to obtain a medal coated with copper. (2)

[10]

QUESTION 10 (Start on a new page.)

Lead-acid batteries have been used in cars for the past 85 years. The equations of the half-reactions that take place in each cell of such batteries are shown below.

$Pb(s) + HSO_4^-(aq) \rightarrow PbSO_4(s) + H^+(aq) + 2e^-$

$PbO_2(s) + 3H^+(aq) + HSO_4^-(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(\ell)$

10.1 Write down the oxidation number of lead (Pb) in $PbSO_4$(s). (1)

10.2 Write down the balanced equation for the net (overall) cell reaction. (3)

10.3 Which ONE of the reactants is the reducing agent in this cell reaction? Give a reason for the answer. (2)

One of the safety concerns related to the lead-acid battery is the dangers associated with recharging (that is reversing the net reaction) of a flat battery. Water in the battery can be electrolysed to produce hydrogen and oxygen gas during recharging.

10.4 Use the Table of Standard Reduction Potentials and write down the half-reaction which explains the formation of oxygen gas. (2)

10.5 Why is the recharging of flat batteries a safety concern? (1)

10.6 If the cell capacity of such a cell is 3,5 A·h, calculate the number of electrons that flow through the cell in 30 minutes. Assume the cell discharges completely during the 30 minutes. (5)
(The charge on one electron is $-1,6 \times 10^{-19}$ C.) **[14]**

TOTAL SECTION B: 125
GRAND 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

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$
$q = I\Delta t$ $W = Vq$	$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ / $E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ / $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{oxidising\,agent} - E^{\theta}_{reducing\,agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$

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 oxidising ability/*Toenemende oksiderende vermoë*

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

Increasing reducing ability/*Toenemende reduserende vermoë*

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

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↓

Increasing reducing ability/*Toenemende reduserende vermoë* ↑