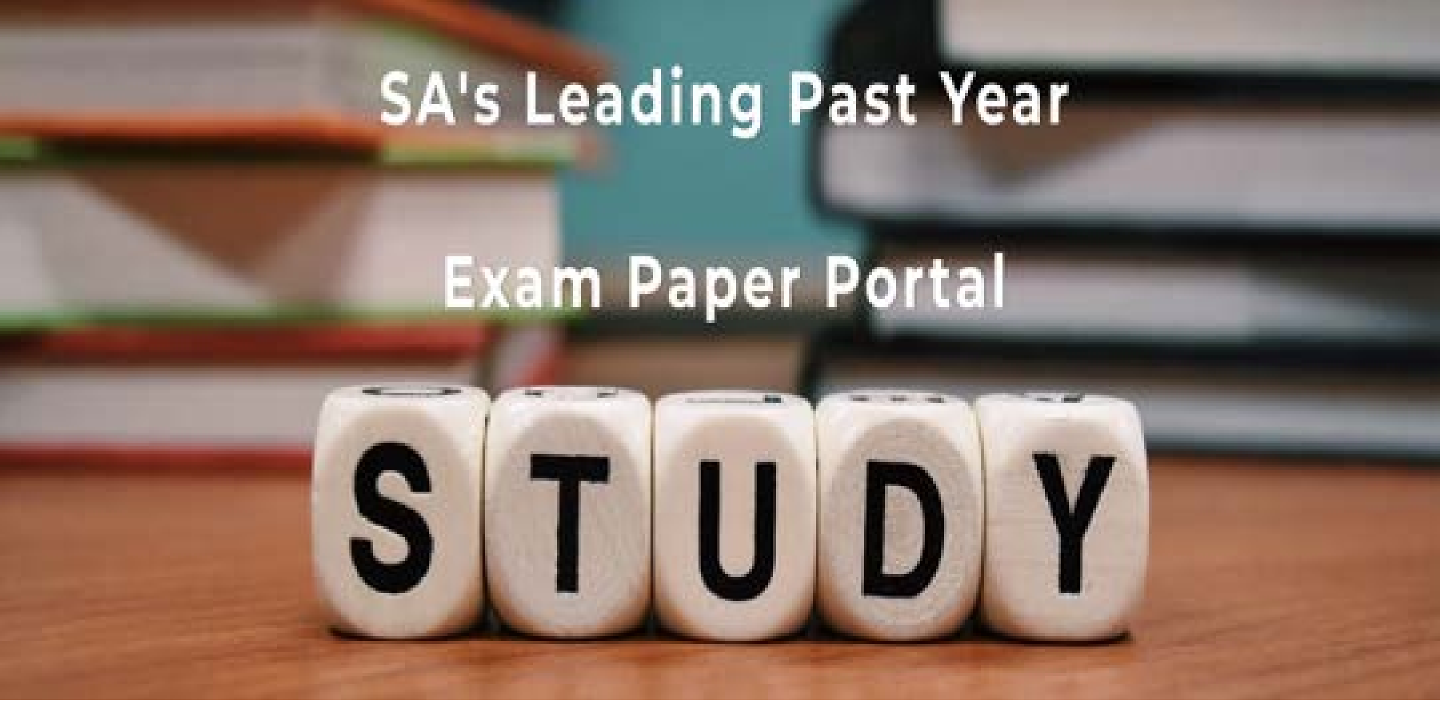

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GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

FEBRUARY/MARCH 2011

MARKS: 150

TIME: 3 hours

This question paper consists of 16 pages and 4 data sheets.

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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 resistance that a fluid offers to flow (1)

1.2 A chemical substance that provides an alternative path of lower activation energy for a chemical reaction (1)

1.3 The acid produced during the contact process (1)

1.4 The name of the electrode in a galvanic (voltaic) cell at which oxidation takes place (1)

1.5 The industrial process for the production of ammonia (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 pairs of compounds correctly represents the products formed during the COMPLETE combustion of octane?

A CO and H_2O

B CO and H_2

C CO_2 and H_2

D CO_2 and H_2O (2)

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

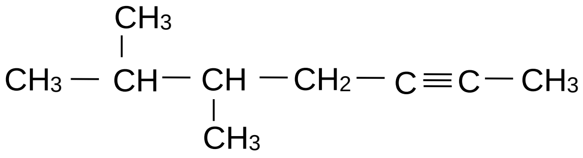
A Ethane and methanoic aid

B Methanol and ethanoic acid

C Ethanol and methanoic acid

D Ethene and methanol (2)

2.3 The structural formula of an organic compound is given below.



$$CH_3 - \overset{CH_3}{\overset{|}{C}H} - \underset{CH_3}{\underset{|}{C}H} - CH_2 - C \equiv C - CH_3$$

The IUPAC name of this compound is ...

A 2,3-dimethylhept-5-yne.

B 5,6-dimethylhept-2-yne.

C 2,3-methylhept-2-yne.

D 5,6-dimethylhept-3-yne. (2)

2.4 The type of compound formed when but-1-ene reacts with water in the presence of a suitable catalyst is a/an ...

A alcohol.

B alkane.

C haloalkane.

D ester. (2)

2.5 The equation below represents a chemical reaction at equilibrium in a closed container.

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

Which ONE of the following changes will increase the yield of HI(g) in the above reaction?

A Increase the temperature

B Decrease the temperature

C Increase the pressure by decreasing the volume

D Decrease the pressure by increasing the volume (2)

2.6 A chemical reaction reaches equilibrium. Which ONE of the following statements regarding this equilibrium is TRUE?

A The concentrations of the individual reactants and products are constant.

B The concentrations of the individual reactants and products are equal.

C The concentrations of the individual reactants are zero.

D The concentrations of the individual products increase until the reaction stops. (2)

2.7 The net (overall) cell reaction taking place in a certain cell is represented as follows:

$$2H_2O(\ell) + \text{electrical energy} \rightarrow 2H_2(g) + O_2(g)$$

Which ONE of the following statements best describes this cell?

The cell is a/an …

A electrolytic cell in which an exothermic reaction occurs.

B electrolytic cell in which an endothermic reaction occurs.

C galvanic (voltaic) cell in which an exothermic reaction occurs.

D galvanic (voltaic) cell in which an endothermic reaction occurs. (2)

2.8 When the net (overall) cell reaction in a galvanic (voltaic) cell reaches equilibrium, the emf of the cell is equal to ...

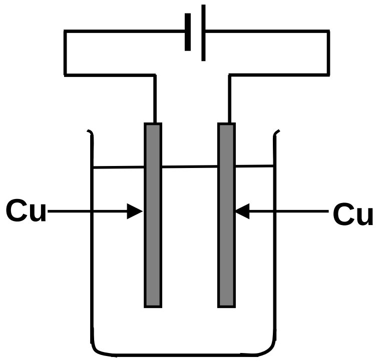
A +2,00 V.

B +1,00 V.

C 0,00 V.

D -1,00 V. (2)

2.9 Copper is purified through electrolysis as represented in the simplified diagram below.



Which ONE of the following statements is CORRECT for this process?

A Cu is oxidised at the negative electrode.

B Cu is reduced at the positive electrode.

C Cu^{2+} ions are reduced at the positive electrode.

D Cu^{2+} ions are reduced at the negative electrode. (2)

2.10 The major products formed in the chlor-alkali industry are ...

A chlorine gas and sodium hydroxide.

B chlorine gas and sodium chloride.

C hydrogen chloride gas and sodium hydroxide.

D chlorine gas and hydrogen chloride gas. (2)
[20]

TOTAL SECTION A: 25

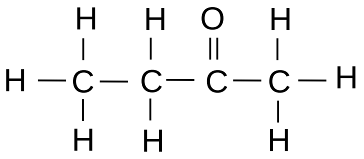
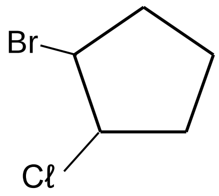
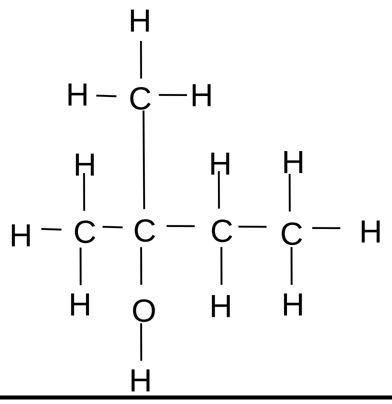
SECTION B

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 your answers to TWO decimal places, where applicable.

QUESTION 3 (Start on a new page.)

Millions of organic compounds are known to date. Four of these compounds, represented by the letters **P, Q, R and S**, are shown in the table below.

P	methanal	**Q**	 $H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\overset{O}{\overset{\Vert}{C}}-\underset{H}{\overset{H}{C}}-H$
R		**S**	

3.1 Write down the following:

3.1.1 Structural formula of the functional group of **P** (2)

3.1.2 Homologous series to which **Q** belongs (1)

3.1.3 Structural formula of an isomer of **Q** (2)

3.1.4 IUPAC name of **R** (2)

3.2 **S** represents an alcohol. Classify this alcohol as primary, secondary or tertiary. (1)

[8]

QUESTION 4 (Start on a new page.)

Knowledge of boiling points can be used to identify chemical compounds. The boiling points of four organic compounds, represented by the letters **A**, **B**, **C** and **D**, are given in the table below.

	COMPOUND	**BOILING POINT (°C)**
A	Propane	-42
B	Pentane	36
C	2-methylbutane	27,8
D	Pentan-1-ol	137

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

4.2 Which ONE of **A** or **B** has the higher vapour pressure? (1)

4.3 An unknown STRAIGHT CHAIN ALKANE has a boiling point of -0,5 °C. Use the information in the table to identify this alkane and write down its IUPAC name. (2)

4.4 **B** and **C** are structural isomers.

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

4.4.2 Explain why **B** has a higher boiling point than **C**. Refer to structure, intermolecular forces and energy in your explanation. (3)

4.5 Explain the difference in the boiling points of **B** and **D**. Refer to intermolecular forces and energy in your explanation. (4)

[14]

QUESTION 5 (Start on a new page.)

5.1 Prop-1-ene, an UNSATURATED hydrocarbon, and compound **X**, a SATURATED hydrocarbon, react with chlorine, as represented by the incomplete equations below.

Reaction I: Prop-1-ene + $C\ell_2 \rightarrow$

Reaction II: **X** + $C\ell_2 \rightarrow$ 2-chlorobutane + **Y**

5.1.1 Give a reason why prop-1-ene is classified as unsaturated. (1)

5.1.2 What type of reaction (ADDITION or SUBSTITUTION) takes place in the following:

(a) Reaction **I** (1)

(b) Reaction **II** (1)

5.1.3 Write down the structural formula of the product formed in Reaction **I**. (2)

5.1.4 Write down the reaction condition necessary for Reaction **II** to take place. (1)

5.1.5 Write down the IUPAC name of reactant **X.** (1)

5.1.6 Write down the name or formula of product **Y.** (1)

5.2 2-chlorobutane can either undergo ELIMINATION or SUBSTITUTION in the presence of a strong base such as sodium hydroxide.

5.2.1 Which reaction will preferably take place when 2-chlorobutane is heated in the presence of CONCENTRATED sodium hydroxide in ethanol? Write down only SUBSTITUTION or ELIMINATION. (1)

5.2.2 Write down the IUPAC name of the major organic compound formed in QUESTION 5.2.1. (2)

5.2.3 Use structural formulae to write down a balanced equation for the reaction that takes place when 2-chlorobutane reacts with a DILUTE sodium hydroxide solution. (6)

5.2.4 Write down the name of the type of substitution reaction that takes place in QUESTION 5.2.3. (1)

5.3 Haloalkanes are used in insecticides (insect killers).

5.3.1 Write down ONE POSITIVE impact of insecticides on human development. (2)

5.3.2 Write down ONE NEGATIVE impact of insecticides on humans. (2)
[22]

QUESTION 6 (Start on a new page.)

Learners perform three investigations (**A**, **B** and **C**) to study three factors which affect the rate of chemical reactions. They use the reaction between solid calcium carbonate ($CaCO_3$) and excess hydrochloric acid ($HC\ell$) solution, represented by the balanced equation below, in all three investigations.

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

EXCESS HYDROCHLORIC ACID is used and the calcium carbonate is COMPLETELY COVERED in all the investigations.

6.1 INVESTIGATION A:

The learners conduct two experiments using the conditions as shown in the table below.

	Mass of $CaCO_3$ (g)	**State of $CaCO_3$**	**Concentration of $HC\ell$ ($mol{\cdot}dm^{-3}$)**	**Temperature of $HC\ell$ (°C)**
Experiment 1	2	powder	0,2	25
Experiment 2	2	lumps	0,2	25

6.1.1 Which factor influencing reaction rate is investigated? (1)

6.1.2 Write down an INVESTIGATIVE QUESTION for this investigation. (2)

6.1.3 The learners now repeat **Experiment 1**, but use 4 g of calcium carbonate in excess acid, instead of 2 g. They find that the rate of the reaction INCREASES.

Give a reason why the rate increases. (2)

6.2 INVESTIGATION B:

The learners conduct two experiments using the conditions as shown in the table below.

	Mass of $CaCO_3$ (g)	State of $CaCO_3$	Concentration of HCℓ ($mol{\cdot}dm^{-3}$)	Temperature of HCℓ (°C)
Experiment 3	2	lumps	0,2	25
Experiment 4	2	lumps	1,0	25

6.2.1 Identify the independent variable in this investigation. (1)

6.2.2 Write down a hypothesis for this investigation. (2)

6.2.3 Is it fair to compare results obtained in **Experiment 3** with that in **Experiment 4**? Give a reason for the answer. (2)

6.2.4 The reactions in **Experiments 3** and **4** both run to completion. How will the yield of CO_2(g) in **Experiment 3** compare to that in **Experiment 4**? Write down only LARGER THAN, SMALLER THAN or EQUAL TO and give a reason for the answer. (2)

6.3 INVESTIGATION C:

The learners conduct two experiments using the conditions as shown in the table below.

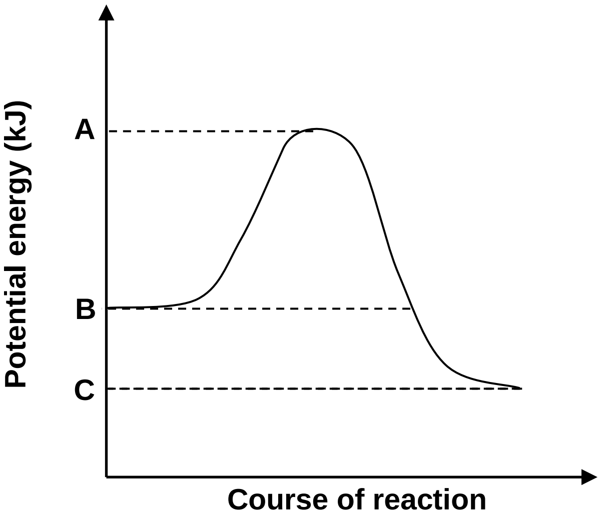
	Mass of $CaCO_3$ (g)	State of $CaCO_3$	Concentration of HCℓ ($mol{\cdot}dm^{-3}$)	Temperature of HCℓ (°C)
Experiment 5	4	powder	0,2	25
Experiment 6	4	powder	0,2	35

6.3.1 How does the average kinetic energy of the particles in the reaction in **Experiment 5** compare to that in **Experiment 6**? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

6.3.2 On the same set of axes, draw sketch graphs of the number of molecules versus the kinetic energy (Maxwell-Boltzmann distribution curves) for each of **Experiment 5** and **Experiment 6**.

- Label the axes.
- Clearly label each graph as **Experiment 5** or **Experiment 6**. (3)

6.4 The graph below shows changes in the potential energy for the reaction between calcium carbonate and hydrochloric acid.



6.4.1 Is this reaction endothermic or exothermic? Give a reason for the answer. (2)

6.4.2 Use the relevant energy values, **A**, **B** and **C**, to write down an expression for each of the following:

(a) The energy of the activated complex (1)

(b) ∆H for the forward reaction (1)

[20]

QUESTION 7 (Start on a new page.)

Fertilisers allow farmers to grow crops in the same soil year after year. However, environmental problems, such as eutrophication, are associated with the application of fertilisers.

7.1 State ONE PRECAUTION that a maize farmer can take to prevent eutrophication. (1)

Nitric acid is an important reactant in the production of ammonium nitrate, a nitrogen-based fertiliser.

7.2 Write down the name of the industrial process for the production of nitric acid. (1)

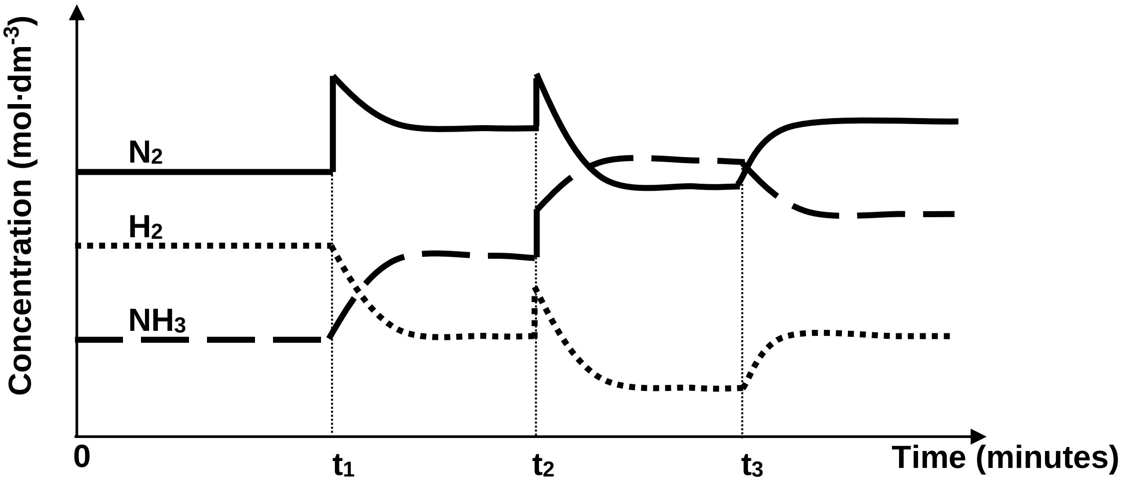
7.3 Write down a balanced equation for the preparation of ammonium nitrate from nitric acid. (3)

A fertiliser company produces ammonia on a large scale at a temperature of 450 °C. The balanced equation below represents the reaction that takes place in a sealed container.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H < 0$$

To meet an increased demand for fertiliser, the management of the company instructs their engineer to make the necessary adjustments to increase the yield of ammonia.

In a trial run on a small scale in the laboratory, the engineer makes adjustments to the TEMPERATURE, PRESSURE and CONCENTRATION of the equilibrium mixture. The graphs below represent the results obtained.



7.4 Identify the changes made to the equilibrium mixture at each of the following times:

7.4.1 t_1 (2)

7.4.2 t_2 (2)

7.4.3 t_3 (2)

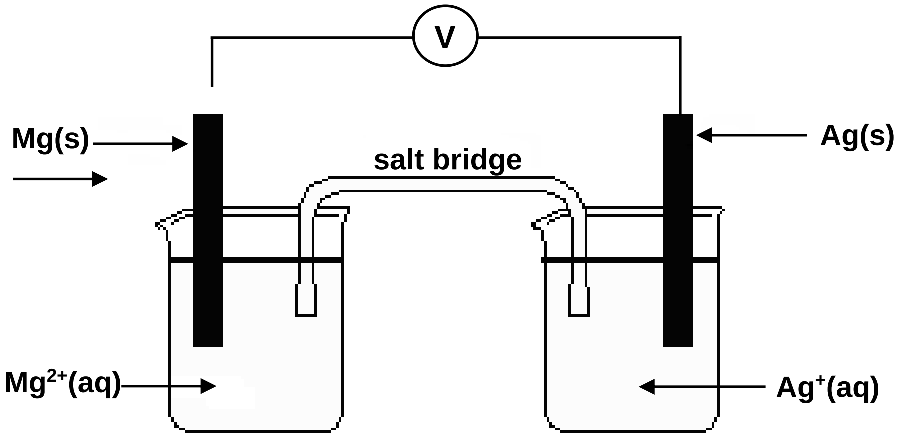
7.5 At which of the above time(s) did the change made to the reaction mixture lead to a higher yield of ammonia? Write down only $\mathbf{t_1}$ and/or $\mathbf{t_2}$ and/or $\mathbf{t_3}$. (2)

7.6 The engineer now injects 5 mol N_2 and 5 mol H_2 into a 5 dm^3 sealed empty container. Equilibrium is reached at 450 °C. Upon analysis of the equilibrium mixture, he finds that the mass of NH_3 is 20,4 g.

Calculate the value of the equilibrium constant (K_c) at 450 °C. (9)
[22]

QUESTION 8 (Start on a new page.)

The diagram below represents a galvanic (voltaic) cell functioning under standard conditions with magnesium and silver as electrodes. A voltmeter connected across the electrodes shows an initial reading of 3,17 V.



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

8.2 State TWO standard conditions under which this cell operates. (2)

8.3 Identify the anode of this cell. Refer to the relative strength of reducing agents to explain how you arrived at the answer. (3)

8.4 Write down the cell notation (symbolic notation) of this cell. (3)

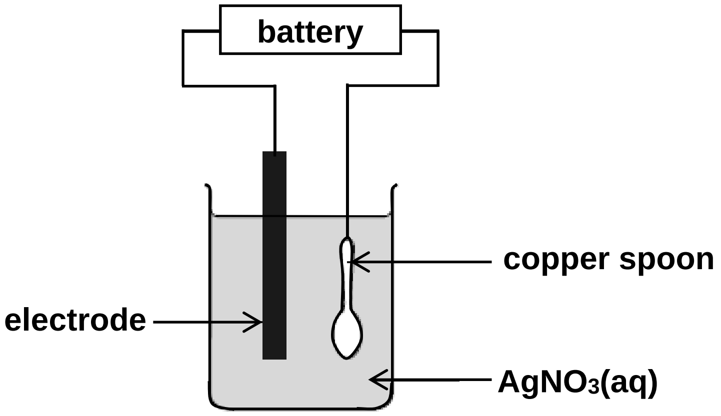
8.5 Write down the balanced equation for the net (overall) cell reaction that takes place in this cell. Omit the spectator ions. (3)

8.6 How will an increase in the concentration of the Ag^{+} ions influence the current that the cell delivers? Write down only INCREASES, DECREASES or REMAINS THE SAME and explain the answer. (3)

[16]

QUESTION 9 (Start on a new page.)

Electroplating is one of the uses of electrolysis. The diagram below shows an electrolytic cell that can be used to plate a copper spoon with silver.



9.1 Define the term *oxidation* in terms of electron transfer. (2)

9.2 What type of half-reaction takes place at the copper spoon? Write down only OXIDATION or REDUCTION. (1)

9.3 Write down a half-reaction that explains the change that occurs on the surface of the copper spoon during electrolysis. (2)

9.4 Name the metal that is labelled 'electrode'. (1)

9.5 Give a reason why the concentration of the $AgNO_3$(aq) remains constant during electrolysis. (2)

[8]

QUESTION 10 (Start on a new page.)

A lead-acid battery (car battery) consists of six cells and has a battery capacity of 20 A·h.

The half-reactions that take place in each cell and their respective standard reduction potentials are represented below:

$PbSO_4(s) + H^+(aq) + 2e^- \rightarrow Pb(s) + HSO_4^-(aq)$ $E^\theta = -0{,}36\ V$

$PbO_2(s) + 3H^+(aq) + HSO_4^-(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(\ell)$ $E^\theta = 1{,}7\ V$

10.1 Are car batteries primary or secondary batteries? (1)

10.2 Write down the equation for the net (overall) cell reaction that takes place in each cell of this battery. (3)

10.3 Calculate the emf of the BATTERY, consisting of six cells, under standard conditions. (5)

10.4 Calculate the maximum time that this battery will be able to supply a constant current of 5 A to an appliance connected to it. Assume that the capacity of the battery remains constant. (4)

10.5 State TWO environmental risks associated with the irresponsible disposal of lead-acid batteries. (2)
[15]

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*

Increasing reducing ability/*Toenemende reduserende 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

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

Increasing oxidising ability/*Toenemende oksiderende vermoë*

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 reducing ability/*Toenemende reduserende vermoë*