basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATION

PHYSICAL SCIENCES P2

CHEMISTRY

2015

MARKS: 150

TIME: 3 hours

This question paper consists of 18 pages and 4 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the appropriate spaces in the ANSWER BOOK.
2. This question paper consists of TEN 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, for example between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable calculator.
7. You may use appropriate mathematical instruments.
8. You are advised to use the attached DATA SHEETS.
9. Show ALL formulae and substitutions in ALL calculations.
10. Round off your final numerical answers to a minimum of TWO decimal places.
11. Give brief motivations, discussions, et cetera where required.
12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Four 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 number (1.1–1.10) in the ANSWER BOOK, for example 1.11 E.

1.1 When a catalyst is used in a chemical reaction, it increases the …

A rate of the reaction.

B amount of products obtained.

C concentration of the products.

D concentration of the reactants. (2)

1.2 Which ONE of the following compounds is produced in the Ostwald process?

A $N_2(g)$

B $NH_3(g)$

C $HNO_3(\ell)$

D $NH_4NO_3(s)$ (2)

1.3 The addition of hydrogen to an alkene is known as ...

A hydration.

B cracking.

C hydrogenation.

D hydrohalogenation. (2)

1.4 Which ONE of the following compounds has the highest boiling point?

A CH_3CH_3

B $CH_3CH_2CH_3$

C $CH_3CH_2CH_2CH_3$

D $CH_3CH_2CH_2CH_2CH_3$ (2)

1.5 Consider the reaction represented by the balanced equation below:

$$2SO_3(g) \rightarrow 2SO_2(g) + O_2(g) \qquad \Delta H = 198\ kJ{\cdot}mol^{-1}$$

Which ONE of the following is TRUE for this reaction?

When 2 moles of $SO_2(g)$ are formed ...

A 198 kJ of energy are absorbed.

B 198 kJ of energy are released.

C 396 kJ of energy are absorbed.

D 396 kJ of energy are released. (2)

1.6 Which ONE of the following compounds belongs to the same homologous series as but-2-yne?

A CH_3CCH

B CH_2CHCH_2

C $CH_3CHCHCH_3$

D $CH_3CH_2CH_2CH_3$ (2)

1.7 The equilibrium constant, K_c, for the reaction $A(g) \rightleftharpoons B(g)$ is 1×10^{-4}.

Which ONE of the following statements is always CORRECT for this reaction?

The mixture at equilibrium consists of ...

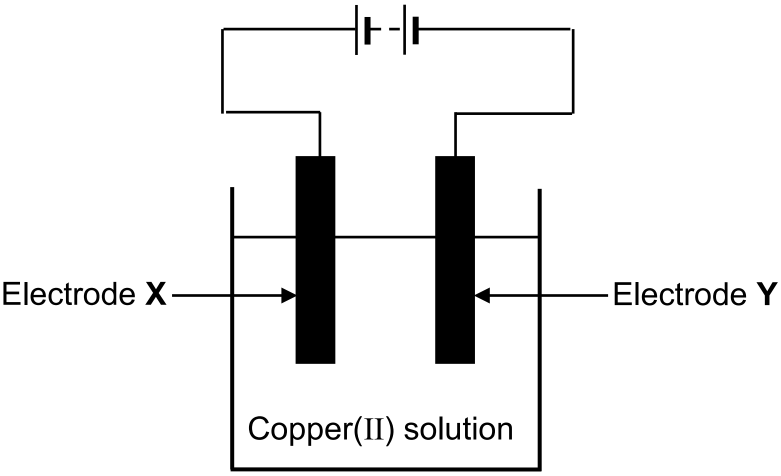
A equal amounts of A(g) and B(g).

B very little of A(g).

C mostly A(g).

D mostly B(g). (2)

1.8 The simplified diagram below shows a cell that can be used to purify copper.



The purification failed. Which ONE of the following is the most likely reason for the failure?

A A DC source is used.

B Electrode **X** is the anode.

C Electrode **Y** is the impure copper.

D Electrode **Y** is a carbon rod. (2)

1.9 A galvanic cell consists of the following half-cells:

$$Pt(s)\ |C\ell_2(g)\ |C\ell^-(aq) \qquad \text{AND} \qquad Cu^{2+}(aq)\ |Cu(s)$$

Which ONE of the following statements is TRUE while the cell is functioning?

A Cu(s) is oxidised.

B $C\ell^-$(aq) is reduced.

C $C\ell_2$(g) acts as reducing agent.

D Cu(s) acts as oxidising agent. (2)

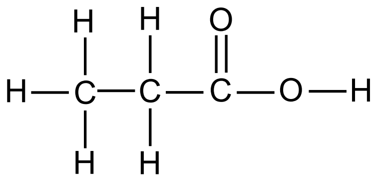
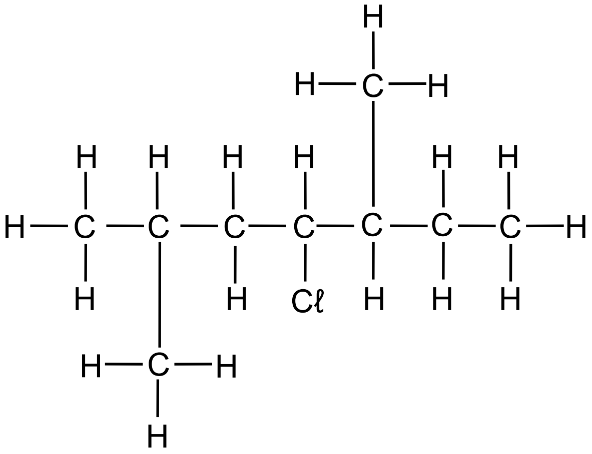
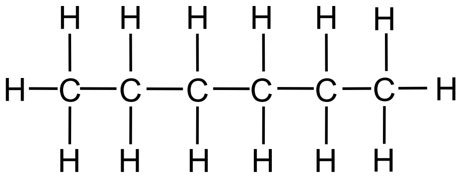
1.10 Which ONE of the following weak acids, each of concentration 0,1 mol·dm^{-3}, has the lowest $H_3O^+(aq)$ concentration?

	ACID	**K_a VALUE**
A	$H_2SO_3(aq)$	$1,2 \times 10^{-2}$
B	$H_2CO_3(aq)$	$4,2 \times 10^{-7}$
C	$(COOH)_2(aq)$	$5,6 \times 10^{-2}$
D	$H_2S(aq)$	$1,0 \times 10^{-7}$

(2)
[20]

QUESTION 2 (Start on a new page.)

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

A		**B**	
C	C_4H_8	**D**	$CH_3CH_2COCH_3$
E	$CH_3CH(CH_3)CH_2OH$	**F**	

Use the information in the table (where applicable) to answer the questions that follow.

2.1 Write down the LETTER that represents a compound that:
(A compound may be used more than once.)

2.1.1 Is a haloalkane (1)

2.1.2 Has a hydroxyl group as functional group (1)

2.1.3 Belongs to the same homologous series as ethanoic acid (1)

2.2 Write down the:

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

2.2.2 IUPAC name of compound **E** (2)

2.2.3 Structural formula of the functional group of compound **D** (1)

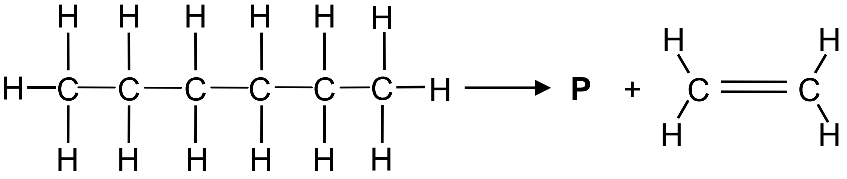
2.3 Compound **C** has CHAIN and POSITIONAL isomers.

2.3.1 Define the term *positional isomer*. (2)

2.3.2 Write down the IUPAC name of each of the TWO positional isomers of compound **C**. (4)

2.3.3 Write down the structural formula of a chain isomer of compound **C**. (2)

2.4 Compound **F** reacts at high pressure and high temperature to form compounds **P** and **Q** as given below.



Compound **F** Compound **Q**

Write down the:

2.4.1 Type of reaction that takes place (1)

2.4.2 IUPAC name of compound **Q** (1)

2.4.3 Molecular formula of compound **P** (1)

Compound **Q** is the monomer of a polymer used to make plastic bags.

2.4.4 Write down the NAME and CONDENSED FORMULA of this polymer. (3)

[23]

QUESTION 3 (Start on a new page.)

Consider the incomplete equations of two reactions below.

X represents the organic product formed in **reaction 1**, which is a SUBSTITUTION REACTION. In **reaction 2**, **X** reacts with reactant **Y** as shown.

Reaction 1: $C_2H_5Br \xrightarrow{\text{strong base}} NaBr + \mathbf{X}$

Reaction 2: $\mathbf{X} + \mathbf{Y} \xrightarrow{\text{Concentrated } H_2SO_4} C_3H_6O_2 + H_2O$

3.1 Consider **reaction 1**. Write down the:

3.1.1 Type of substitution reaction that takes place (1)

3.1.2 TWO reaction conditions (2)

3.1.3 IUPAC name of compound **X** (1)

3.2 Consider **reaction 2**. Write down the:

3.2.1 Type of reaction that takes place (1)

3.2.2 Structural formula of compound **Y** (2)

3.2.3 IUPAC name of the organic product (2)
[9]

QUESTION 4 (Start on a new page.)

The table below shows five organic compounds represented by the letters **A** to **E**.

A	CH_4
B	CH_3CH_3
C	$CH_3CH_2CH_3$
D	$CH_3CH_2CH_2CH_3$
E	CH_3CH_2OH

4.1 Is compound **B** SATURATED or UNSATURATED? Give a reason for the answer. (2)

Consider the boiling points of compounds **A** to **E** given in random order below and use them, where applicable, to answer the questions that follow.

0 °C	- 162 °C	- 42 °C	- 89 °C	78 °C

4.2 Write down the boiling point of:

4.2.1 Compound **C** (1)

4.2.2 Compound **E** (1)

4.3 Explain the difference in boiling points of compounds **C** and **E** by referring to the TYPE of intermolecular forces present in EACH of these compounds. (3)

4.4 Does vapour pressure INCREASE or DECREASE from compounds **A** to **D**? Fully explain the answer. (4)

4.5 How will the vapour pressure of 2-methylpropane compare to the vapour pressure of compound **D**? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)
[12]

QUESTION 5 (Start on a new page.)

A group of learners uses the reaction of clean magnesium ribbon with dilute hydrochloric acid to investigate factors that influence reaction rate. The balanced equation for the reaction is:

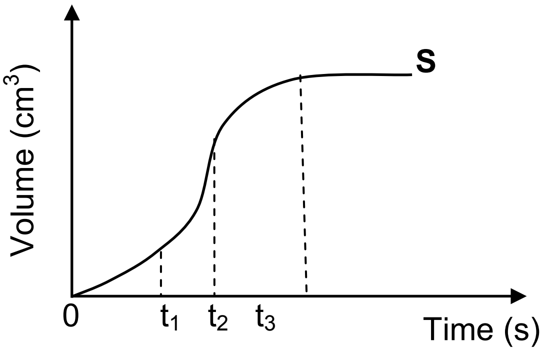
$$Mg(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + H_2(g) \qquad \Delta H < 0$$

5.1 Is the above reaction EXOTHERMIC or ENDOTHERMIC? Give a reason for the answer. (2)

5.2 In one of the experiments 5 g magnesium ribbon was added to the hydrochloric acid solution.

5.2.1 If 30 cm^3 dilute hydrochloric acid solution of concentration 1,5 $mol{\cdot}dm^{-3}$ is USED UP in 1 minute, calculate the average reaction rate in $mol{\cdot}s^{-1}$. (5)

The volume of hydrogen gas produced as a function of time in this experiment is represented by graph **S** below. (The graph is NOT drawn to scale.)

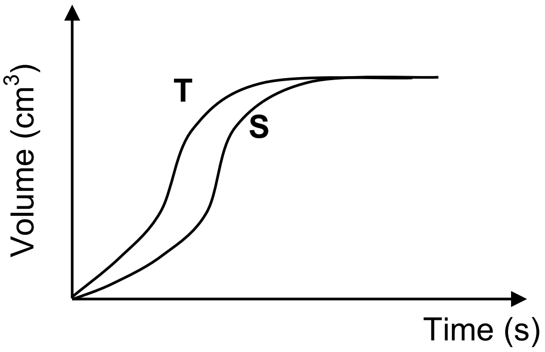


5.2.2 How does the rate of the reaction change between:
(Write down INCREASES, DECREASES or NO CHANGE.)

(a) t_1 and t_2
Use the collision theory to explain the answer. (4)

(b) t_2 and t_3
Give a reason for the answer without referring to the graph. (2)

5.3 In another experiment they add 5 g of magnesium to 30 cm^3 of dilute hydrochloric acid of concentration 1,5 $mol \cdot dm^{-3}$. They obtained graph **T** below. (The graph is NOT drawn to scale.)



Give TWO possible reasons why graph **T** differs from graph **S**. (2)

[15]

QUESTION 6 (Start on a new page.)

Initially excess $NH_4HS(s)$ is placed in a 5 dm^3 container at 218 °C. The container is sealed and the reaction is allowed to reach equilibrium according to the following balanced equation:

$$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g) \qquad \Delta H > 0$$

6.1 State Le Chatelier's principle. (2)

6.2 What effect will each of the following changes have on the amount of $NH_3(g)$ at equilibrium? Write down only INCREASES, DECREASES or REMAINS THE SAME.

6.2.1 More $NH_4HS(s)$ is added (1)

6.2.2 The temperature is increased (1)

6.3 The equilibrium constant for this reaction at 218 °C is $1,2 \times 10^{-4}$.

Calculate the minimum mass of $NH_4HS(s)$ that must be sealed in the container to obtain equilibrium. (6)

The pressure in the container is now increased by decreasing the volume of the container at constant temperature.

6.4 How will this change affect the number of moles of $H_2S(g)$ produced? Fully explain the answer. (3)

[13]

QUESTION 7 (Start on a new page.)

Anhydrous oxalic acid is an example of an acid that can donate two protons and thus ionises in two steps as represented by the equations below:

I: $(COOH)_2(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + H(COO)_2^-(aq)$

II: $H(COO)_2^-(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + (COO)_2^{2-}(aq)$

7.1 Write down:

7.1.1 ONE word for the underlined phrase in the above sentence (1)

7.1.2 The FORMULA of each of the TWO bases in **reaction II** (2)

7.1.3 The FORMULA of the substance that acts as ampholyte in **reactions I** and **II**. Give a reason for the answer. (2)

7.2 Give a reason why oxalic acid is a weak acid. (1)

7.3 A standard solution of $(COOH)_2$ of concentration 0,20 mol·dm^{-3} is prepared by dissolving a certain amount of $(COOH)_2$ in water in a 250 cm^3 volumetric flask.

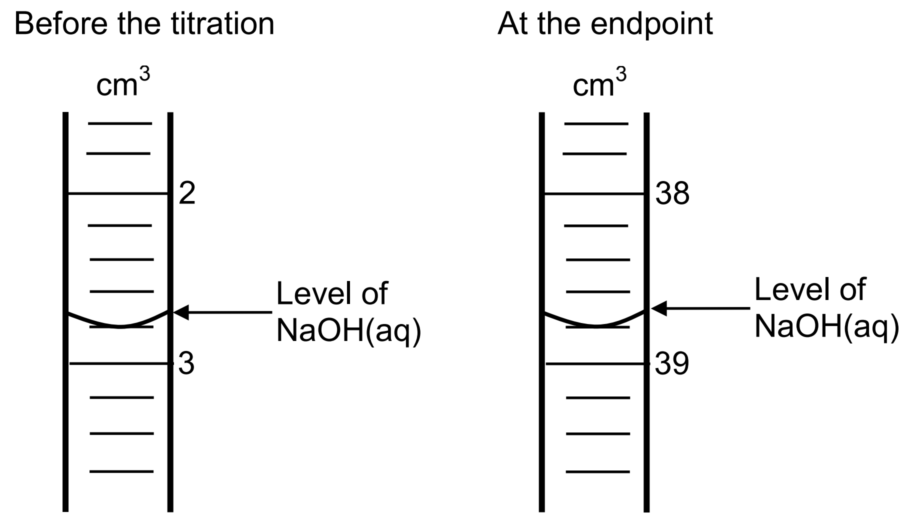
Calculate the mass of $(COOH)_2$ needed to prepare the standard solution. (4)

7.4 During a titration 25 cm^3 of the standard solution of $(COOH)_2$ prepared in QUESTION 7.3 is neutralised by a sodium hydroxide solution from a burette.

The balanced equation for the reaction is:

$$(COOH)_2(aq) + 2NaOH(aq) \rightarrow (COONa)_2(aq) + 2H_2O(\ell)$$

The diagrams below show the burette readings before the titration commenced and at the endpoint respectively.

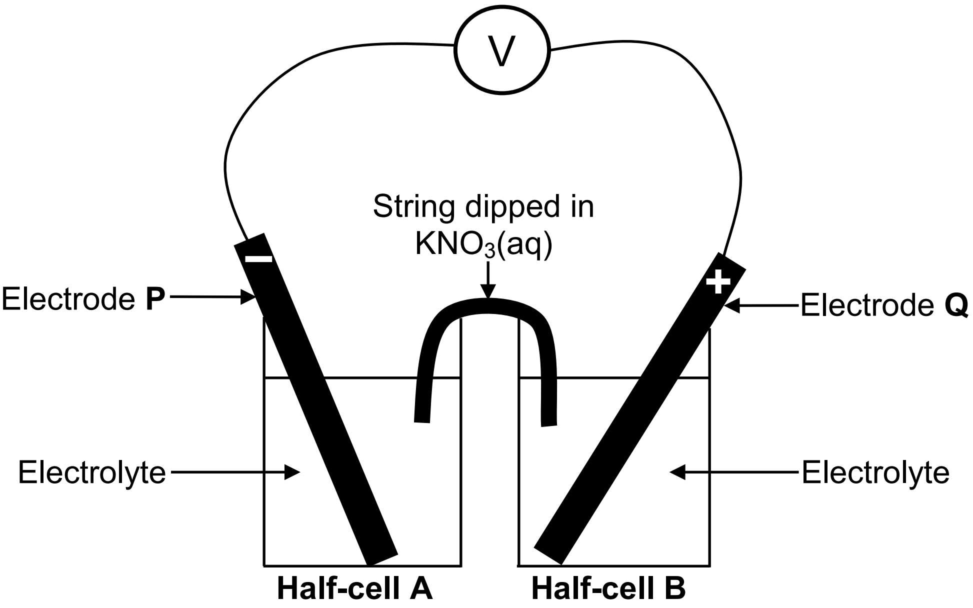


7.4.1 Use the burette readings and calculate the concentration of the sodium hydroxide solution. (5)

7.4.2 Write down a balanced equation that explains why the solution has a pH greater than 7 at the endpoint. (3)
[18]

QUESTION 8 (Start on a new page.)

Learners set up an electrochemical cell, shown in the simplified diagram below, using magnesium and lead as electrodes. Nitrate solutions are used as electrolytes in both half-cells.



8.1 What type of reaction (NEUTRALISATION, REDOX or PRECIPITATION) takes place in this cell? (1)

8.2 Which electrode, **P** or **Q**, is magnesium? Give a reason for the answer. (2)

8.3 Write down the:

8.3.1 Standard conditions under which this cell functions (2)

8.3.2 Cell notation for this cell (3)

8.3.3 NAME or FORMULA of the oxidising agent in the cell (1)

8.4 Calculate the initial emf of the cell above under standard conditions. (4)

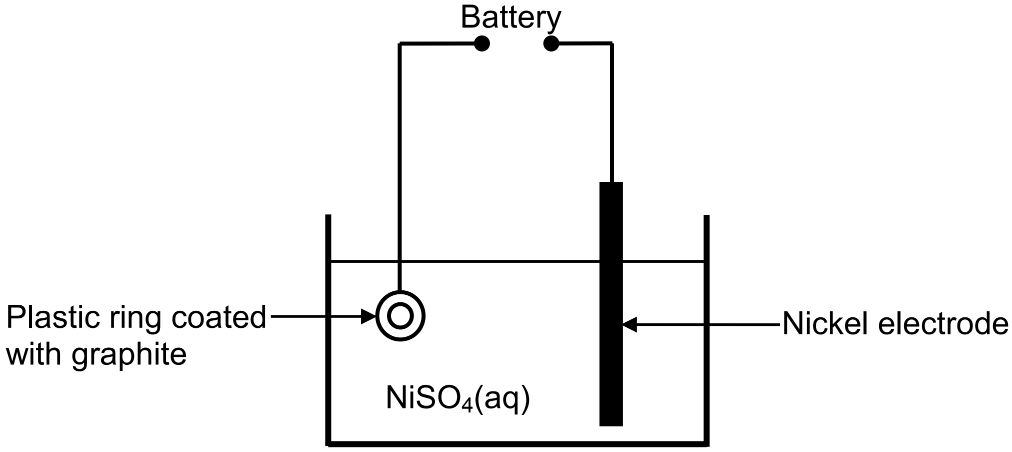
8.5 How will the voltmeter reading change if the:
(Write down only INCREASES, DECREASES or REMAINS THE SAME.)

8.5.1 Size of electrode **P** is increased (1)

8.5.2 Initial concentration of the electrolyte in half-cell **B** is increased (1)
[15]

QUESTION 9 (Start on a new page.)

The diagram below shows a simplified electrolytic cell that can be used to electroplate a plastic ring with nickel. Prior to electroplating the ring is covered with a graphite layer.



9.1 Define the term *electrolyte*. (2)

9.2 Give ONE reason why the plastic ring must be coated with graphite prior to electroplating. (1)

9.3 Write down the:

9.3.1 Half-reaction that occurs at the plastic ring (2)

9.3.2 NAME or FORMULA of the reducing agent in the cell.
Give a reason for the answer. (2)

9.4 Which electrode, the **RING** or **NICKEL**, is the cathode? Give a reason for the answer. (2)

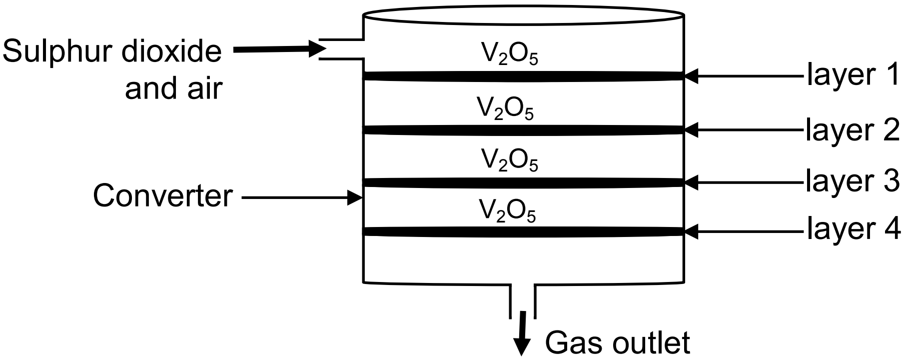
The nickel electrode is now replaced with a carbon rod.

9.5 How will the concentration of the electrolyte change during electroplating? Write down only INCREASES, DECREASES or NO CHANGE. Give a reason for the answer. (2)
[11]

QUESTION 10 (Start on a new page.)

The industrial process for the preparation of sulphuric acid involves a series of stages.

The second stage in this process involves the conversion of sulphur dioxide into sulphur trioxide in a converter as illustrated below. In the converter the gases are passed over vanadium pentoxide (V_2O_5) placed in layers as shown below.



10.1 Write down the:

10.1.1 Balanced equation for the reaction taking place in the converter (3)

10.1.2 Function of the vanadium pentoxide (1)

The table below shows data obtained during the second stage.

VANADIUM PENTOXIDE LAYER	TEMPERATURE OF GAS BEFORE THE REACTION (°C)	TEMPERATURE OF GAS AFTER THE REACTION (°C)	PERCENTAGE OF REACTANT CONVERTED TO PRODUCT
1	450	600	66
2	450	518	85
3	450	475	93
4	450	460	99,5

10.2 Is the reaction in the second stage EXOTHERMIC or ENDOTHERMIC? Refer to the data in the table to give a reason for the answer. (2)

10.3 After the conversion at each layer the gases are cooled down to 450 °C. Fully explain why the gases must be cooled to this temperature. (3)

10.4 During the third stage sulphur trioxide is dissolved in sulphuric acid rather than in water to produce oleum.

10.4.1 Write down the FORMULA of oleum. (1)

10.4.2 Give a reason why sulphur trioxide is not dissolved in water. (1)

10.5 Sulphuric acid reacts with ammonia to form a fertiliser. Write down a balanced equation for this reaction. (3)

[14]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

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

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

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

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

TABLE 3: THE PERIODIC TABLE OF ELEMENTS

KEY/*SLEUTEL*

Atomic number / ***Atoomgetal***: 29

Electronegativity / ***Elektronegatiwiteit***: 1,9

Symbol / ***Simbool***: Cu

Approximate relative atomic mass / ***Benaderde relatiewe atoommassa***: 63,5

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 **H** 1																	2 **He** 4
3 1,0 **Li** 7	4 1,5 **Be** 9											5 2,0 **B** 11	6 2,5 **C** 12	7 3,0 **N** 14	8 3,5 **O** 16	9 4,0 **F** 19	10 **Ne** 20
11 0,9 **Na** 23	12 1,2 **Mg** 24											13 1,5 **Aℓ** 27	14 1,8 **Si** 28	15 2,1 **P** 31	16 2,5 **S** 32	17 3,0 **Cℓ** 35,5	18 **Ar** 40
19 0,8 **K** 39	20 1,0 **Ca** 40	21 1,3 **Sc** 45	22 1,5 **Ti** 48	23 1,6 **V** 51	24 1,6 **Cr** 52	25 1,5 **Mn** 55	26 1,8 **Fe** 56	27 1,8 **Co** 59	28 1,8 **Ni** 59	29 1,9 **Cu** 63,5	30 1,6 **Zn** 65	31 1,6 **Ga** 70	32 1,8 **Ge** 73	33 2,0 **As** 75	34 2,4 **Se** 79	35 2,8 **Br** 80	36 **Kr** 84
37 0,8 **Rb** 86	38 1,0 **Sr** 88	39 1,2 **Y** 89	40 1,4 **Zr** 91	41 **Nb** 92	42 1,8 **Mo** 96	43 1,9 **Tc**	44 2,2 **Ru** 101	45 2,2 **Rh** 103	46 2,2 **Pd** 106	47 1,9 **Ag** 108	48 1,7 **Cd** 112	49 1,7 **In** 115	50 1,8 **Sn** 119	51 1,9 **Sb** 122	52 2,1 **Te** 128	53 2,5 **I** 127	54 **Xe** 131
55 0,7 **Cs** 133	56 0,9 **Ba** 137	57 **La** 139	72 1,6 **Hf** 179	73 **Ta** 181	74 **W** 184	75 **Re** 186	76 **Os** 190	77 **Ir** 192	78 **Pt** 195	79 **Au** 197	80 **Hg** 201	81 1,8 **Tℓ** 204	82 1,8 **Pb** 207	83 1,9 **Bi** 209	84 2,0 **Po**	85 2,5 **At**	86 **Rn**
87 0,7 **Fr**	88 0,9 **Ra** 226	89 **Ac**															
				58 **Ce** 140	59 **Pr** 141	60 **Nd** 144	61 **Pm**	62 **Sm** 150	63 **Eu** 152	64 **Gd** 157	65 **Tb** 159	66 **Dy** 163	67 **Ho** 165	68 **Er** 167	69 **Tm** 169	70 **Yb** 173	71 **Lu** 175
				90 **Th** 232	91 **Pa**	92 **U** 238	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**	103 **Lr**

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

Increasing oxidising ability/*Toenemende oksiderende vermoë*

Increasing reducing ability/*Toenemende reduserende vermoë*

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

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

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↓

Increasing reducing ability/*Toenemende reduserende vermoë* ↑

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