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Basic Education

KwaZulu-Natal Department of Basic Education

REPUBLIC OF SOUTH AFRICA

PHYSICAL SCIENCES P2 (CHEMISTRY)

PREPARATORY EXAMINATION

SEPTEMBER 2016

**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

MARKS : 150

TIME : 3 Hours

This question paper consists of 18 pages and 4 Data Sheets.

INSTRUCTIONS AND INFORMATION TO CANDIDATES

1. Write your name and other information in the appropriate spaces on the ANSWER BOOK.
2. The 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 sub-questions, for example between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable pocket 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 where applicable.
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. Write only the letter (A – D) next to the question number (1.1 – 1.10) in the ANSWER BOOK.

1.1 The main product formed during the Ostwald process is ...

- A Ammonia.
- B Ammonium nitrate.
- C Nitric acid.
- D Sulphuric acid.

(2)

1.2 Which of the following compounds is an isomer of propanoic acid?

- A propan -1,2,3 - triol
- B 2 - methylpropan -1 - ol
- C ethyl ethanoate
- D methyl ethanoate

(2)

1.3 The boiling points of helium and argon are – 269 °C and – 186 °C respectively. The difference in boiling point is due to the presence of stronger ...

- A ionic bonds between argon atoms.
- B Van der Waals forces between argon atoms.
- C hydrogen bonds between helium atoms.
- D covalent bonds between helium atoms.

(2)

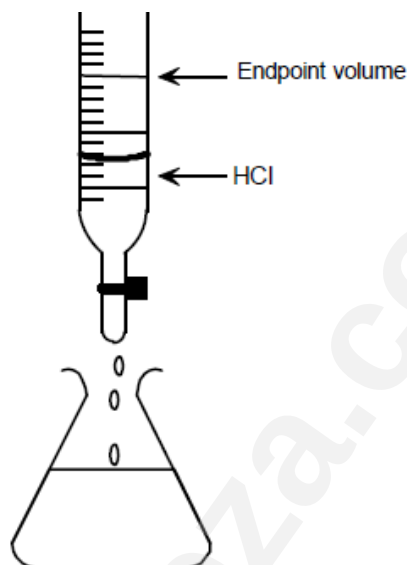
1.4 If base X is titrated against acid Y, the pH of the solution at the end point is 8.

The base X and acid Y are most likely to be:

	X	Y
A	NaOH	CH ₃ COOH
B	Na ₂ CO ₃	HCl
C	NaOH	H ₂ SO ₄
D	Na ₂ CO ₃	CH ₃ COOH

(2)

- 1.5 A group of learners were doing a titration experiment using HCl and NaOH, as shown below. They accidentally exceed the endpoint.



Which one of the following is **correct** for the solution now in the beaker?

- A $[H^+] < [OH^-]$ and $pH < 7$
 B $[H^+] = [OH^-]$ and $pH < 7$
 C $[H^+] > [OH^-]$ and $pH < 7$
 D $[H^+] > [OH^-]$ and $pH = 7$

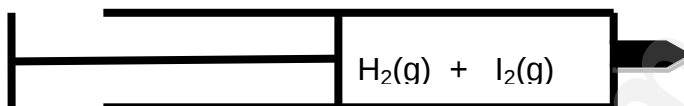
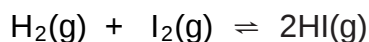
(2)

- 1.6 Dilute nitric acid is gradually added to a flask of distilled water at 25°C . How does this affect the hydrogen ion concentration $[H^+]$ and the ionisation constant (K_w) of water?

	$[H^+]$	(K_w)
A	Increases	Increases
B	Does not increase	Increases
C	Increases	Stay the same
D	Does not increase	Stay the same

(2)

- 1.7 A mixture of $\text{H}_2(\text{g})$ and $\text{I}_2(\text{g})$ is sealed in a gas syringe. The mixture is then allowed to reach equilibrium at a constant temperature according to the equation:

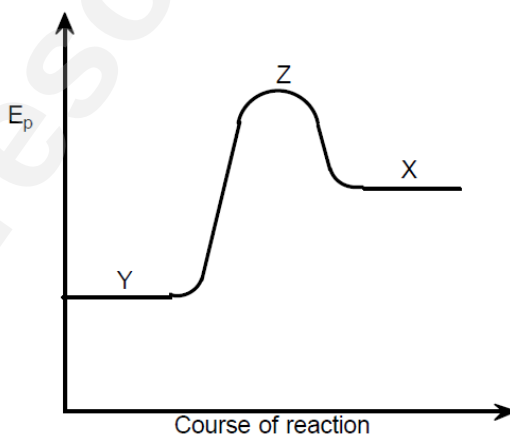


What will happen to the **concentration and yield** of HI if the piston is moved inwards while the temperature remains constant?

	HI	Yield of HI
A	Increases	Stay the same
B	Decreases	Stay the same
C	Decreases	Increases
D	Increases	Decreases

(2)

- 1.8 Consider the potential-energy diagram for the reaction:

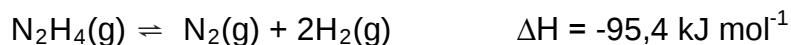


Which one of the following is **correct**?

- A X represents the energy of CaCO_3
- B Y represents the energy of $\text{CaO} + \text{CO}_2$
- C X represents the energy of $\text{CaO} + \text{CO}_2$
- D Z represents a catalyst

(2)

1.9 The following reaction takes place in a closed container:



Which one of the statements below is **correct**?

- A Increasing the temperature favours the forward reaction.
- B Increasing the temperature increases the K_c value.
- C Increasing the temperature has no effect on the amount of products formed.
- D Increasing the temperature speeds up both forward and reverse reactions. (2)

1.10 A polymer formed as a result of addition polymerisation is most likely to be derived from a monomer that is ...

- A Unsaturated
- B A hydrocarbon
- C An alcohol
- D A carboxylic acid (2)

[20]

QUESTION 2 (Start on a new page.)

Consider the following representation of organic molecules **A** to **J** listed in the table below to answer the questions that follow:

A	Butan-2-ol	B	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{O}-\text{H} \end{array}$
C	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{C}-\text{CH}_3 \\ \\ \text{OH} \end{array}$	D	$\text{CH}_2 = \text{CH}-\text{Cl}$
E	$\begin{array}{c} \text{H} \quad \text{O} \\ \quad \\ \text{CH}_3-\text{CH}_2-\text{C}-\text{C}-\text{H} \\ \\ \text{CH}_2 \\ \\ \text{CH}_3 \end{array}$	F	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{O} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$
G	4-methylpentanoic acid	H	Pentanal
I	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$	J	C_4H_8

- 2.1 Choose from the list a substance that is used in the laboratory preparation of **F**.
Write down the **LETTER** only. (2)
- 2.2 Which ONE of the above represents a SECONDARY alcohol? (1)
- 2.3 Write down the name for compound **D**. (2)
- 2.4 Write down the letter that represents an aldehyde. (1)
- 2.5 Write down the homologous series to which compounds **B** belongs. (1)
- 2.6 Draw the STRUCTURAL FORMULA of compound **G**. (2)
- 2.7 Draw the STRUCTURAL FORMULA of the functional group for compound **H**. (1)

[10]

QUESTION 3 (Start on a new page.)

3.1 The boiling point of methane is -161°C and the boiling point of pentane is 36°C .

Comments made by Rama, a Grade 12 learner:

"Pentane has a longer carbon chain than methane therefore more bonds need to be broken to separate the molecule into its individual atoms. Breaking of these bonds requires energy which explains why pentane has a higher boiling point than methane."

3.1.1 Consider Rama's explanation and EXPLAIN why it is **INCORRECT**. (1)

3.1.2 Provide a correct explanation for the difference in the boiling points. (2)

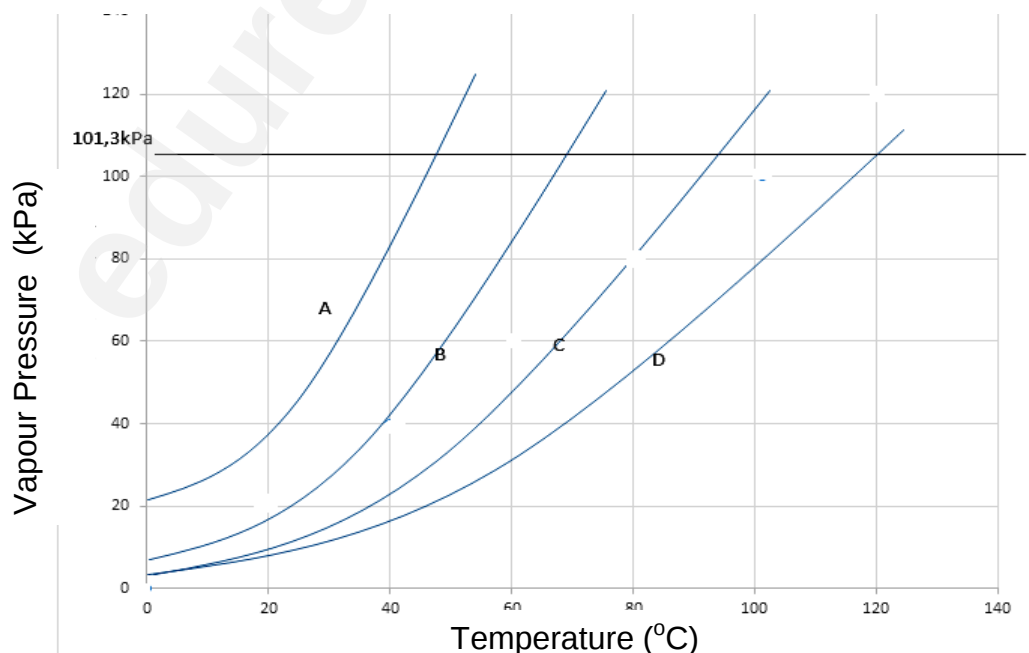
3.1.3 Write down the NAME and draw the STRUCTURAL FORMULA of an isomer of pentane which has a lower boiling point than pentane. (3)

3.2 Draw the STRUCTURAL FORMULAE of the positional isomer of but-1-ene. (2)

The following graph shows the relationship between vapour pressure of organic molecules and temperature. The bold line indicates the external atmospheric pressure. The four curves (A, B, C and D) represent the organic molecules belonging to the following homologous series: **an unbranched alkane, a branched alkane, an unbranched primary alcohol and an unbranched aldehyde.**

All four molecules have the same number of C atoms

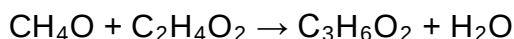
VAPOUR PRESSURE OF ORGANIC COMPOUNDS AT DIFFERENT TEMPERATURES



- 3.3 Define the term **homologous series**. (2)
- 3.4 Which ONE of the four curves (**A, B, C** or **D**) represents the
- 3.4.1 Straight chain alkane (1)
- 3.4.2 Single branched alkane (1)
- 3.5 Fully EXPLAIN your choice in QUESTION 3.4 by referring the TYPE and STRENGTH of the INTERMOLECULAR FORCES. (3)
- 3.6 Which ONE of the four curves (**A, B, C** or **D**) represents the
- 4.4.1 Primary alcohol (1)
- 4.4.2 Aldehyde (1)
- [17]**

QUESTION 4 (Start on a new page.)

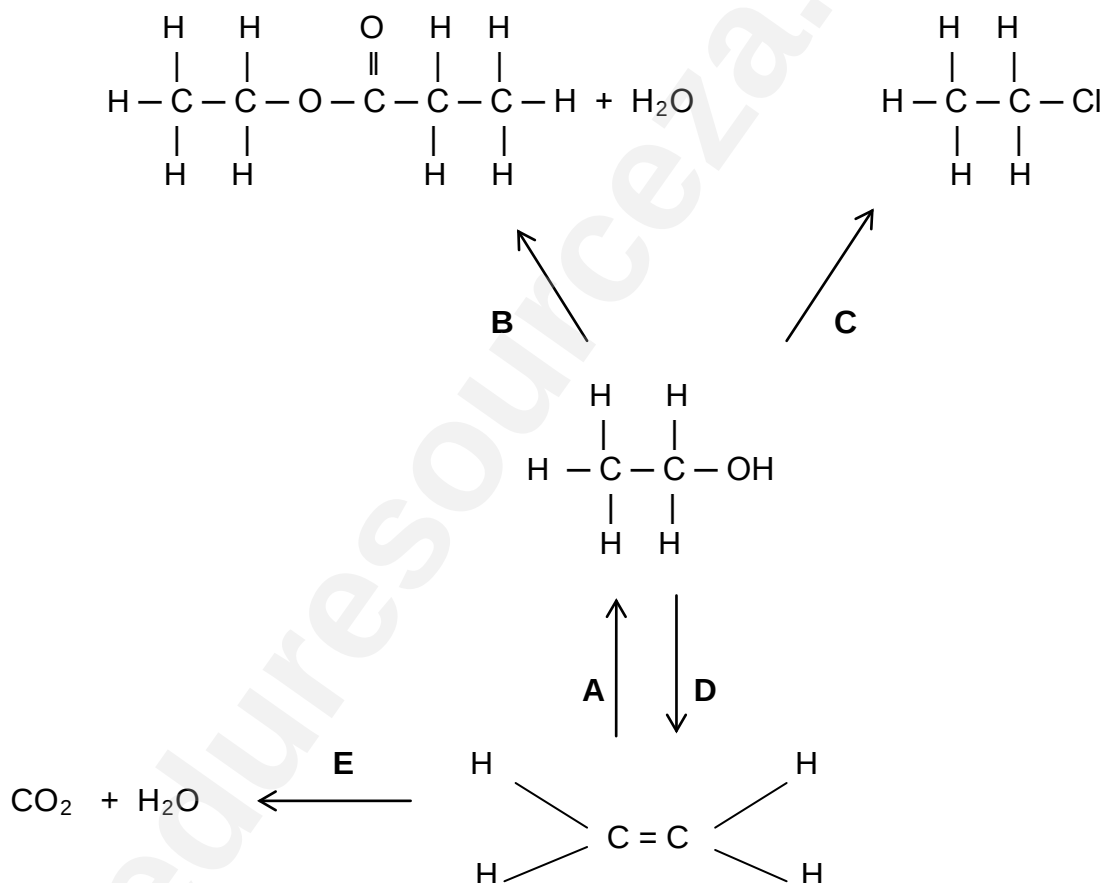
- 4.1 A group of Grade 12 learners are in a school laboratory preparing an ester using methanol and ethanoic acid. The balanced chemical equation for this reaction is given below:



4.1.1 Write down the IUPAC name of the ester formed. (2)

4.1.2 When 50 g of impure methanol fully reacts with excess ethanoic acid, it produces 68,88 g $\text{C}_3\text{H}_6\text{O}_2$. Calculate the percentage purity of the methanol. (5)

4.2



4.2.1 Name the type of reaction indicated by A, C, D and E. (4)

4.2.2 The product of reaction C can be converted, by a single reaction, to the product of reaction D. State the necessary reagents and conditions for this conversion to take place. (3)

4.2.3 Reactions B and D use the same catalyst. Write down the name or formula of this catalyst. (1)

4.2.4 The product of reaction D can undergo polymerization. Name the polymer that will be produced. (1)

4.2.5 Using condensed formulae, write a balanced reaction for the combustion of ethanol. (3)

[19]**QUESTION 5 (Start on a new page)**

Ketiwe conducts an experiment to investigate the various factors that influence the rate of chemical reactions. She places a sample of calcium carbonate in a beaker. The beaker is placed on a sensitive balance and an excess of hydrochloric acid (HCl) is added.

The following reaction occurs:

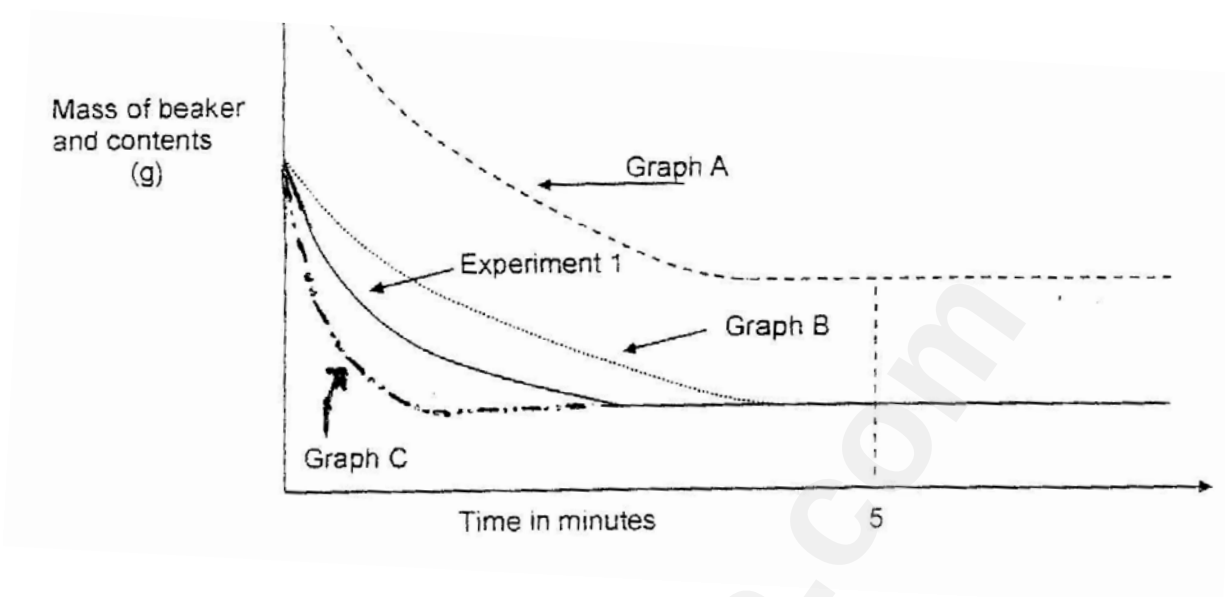


Ketiwe repeats the experiment a number of times under different conditions, always with the same volume of HCl, which remains in excess.

The following table summarizes the different experimental conditions for four of her experiments.

Expt	Mass of CaCO_3 (g)	Concentration of HCl ($\text{mol}\cdot\text{dm}^{-3}$)	Temperature of HCl ($^{\circ}\text{C}$)	State of CaCO_3
1	10	2	25	granules
2	10	2	15	granules
3	20	2	25	granules
4	10	2	25	powder

During each experiment the mass of the beaker and its contents is recorded every minute. The graphs below indicate the changes in mass of the beaker and its contents during the reaction, as a function of time, for the four experiments:

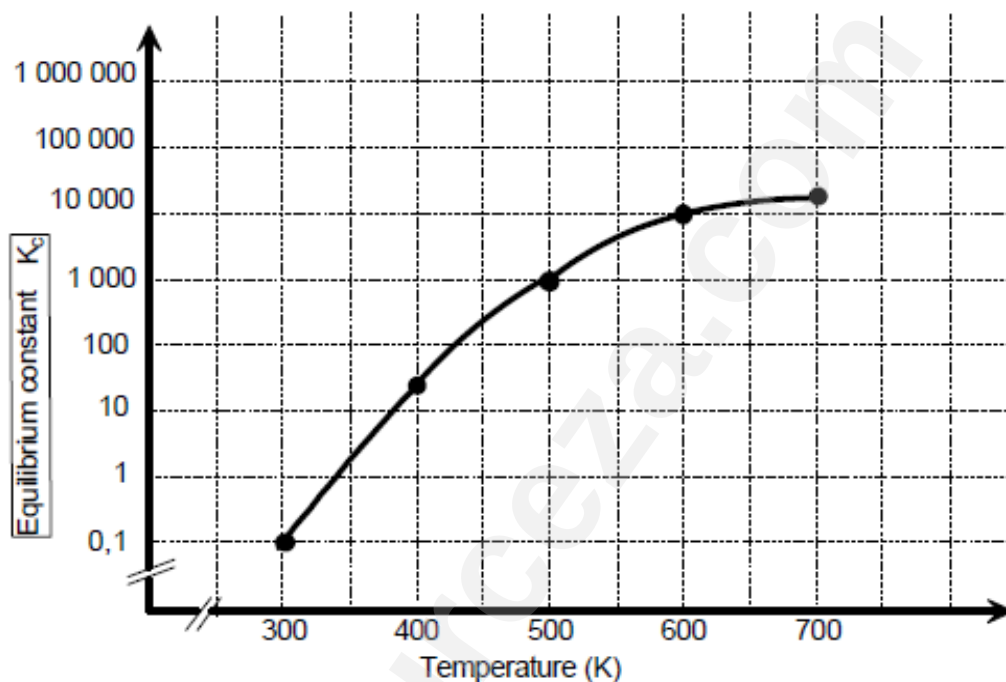
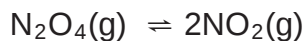


- 5.1 What is meant by the rate of a chemical reaction? (2)
- 5.2 Name the quantity that was kept constant during all 4 experiments. (1)
- 5.3 Give a reason for the decrease in mass as each reaction progresses. (2)
- 5.4 Why are all the graphs horizontal lines after five minutes? (2)
- 5.5 Which one of the graphs (A, B, or C) represents the results of:
- 5.5.1 Experiment 2 (1)
- 5.5.2 Experiment 3 (1)
- 5.5.3 Experiment 4 (1)
- 5.6 If a suitable catalyst is used in experiment 1, which of the graphs (A,B or C) will be obtained? Explain your answer. (4)

[14]

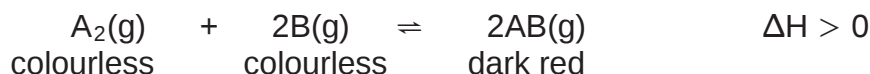
QUESTION 6 (Start on a new page)

- 6.1 The graph below shows the effect of a temperature change on the value of K_c for the following reaction taking place in a closed container:



- 6.1.1 What effect does an increase in temperature have on the amount of NO_2 formed? (1)
- 6.1.2 Which reaction was favoured due to an increase in temperature?
Write only FORWARD or REVERSE. (1)
- 6.1.3 State Le Chatelier's Principle. (2)
- 6.1.4 Using Le Chatelier's Principle, explain whether the forward reaction is EXOTHERMIC or ENDOTHERMIC. (4)
- 6.1.5 Write down TWO factors, other than temperature, that can be used to increase the rate of the forward reaction at 500K. (2)

- 6.2 Consider the hypothetical reaction that takes place between A_2 and B in a closed container.



X mol of gas A_2 and 2,0 mol of gas B are sealed in a $1,0 \text{ dm}^3$ container.

After a few minutes equilibrium is reached and the contents of the container turns light red.

At equilibrium it is found that 0,40 mol of gas AB is present in the container.

The value of K_c is 0,50.

Determine X, the quantity (in mol) of gas A_2 that was originally sealed in the container.

(8)

[18]

QUESTION 7 (Start on a new page.)

- 7.1 Magnesium hydroxide ($Mg(OH)_2$) is often used to relieve an upset stomach.

The pH of the $HCl(aq)$ in a person's stomach is 1.

- 7.1.1 Calculate the concentration of the hydrochloric acid in the person's stomach. (3)

- 7.1.2 Will the pH in the stomach **INCREASE**, **DECREASE** or **STAY THE SAME** after taking a dose of $Mg(OH)_2$? (1)

- 7.1.3 A person takes a dose of $Mg(OH)_2$. Write down the balanced equation for the reaction that takes place in the stomach. (3)

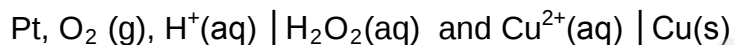
- 7.2 Explain what is meant by a neutralization reaction. (2)

- 7.3 12 cm^3 of NaOH of concentration $0,1 \text{ mol} \cdot \text{dm}^{-3}$ and 48 cm^3 of $Ba(OH)_2$ of unknown concentration are mixed in a large flask, and the solution is homogenized. This solution is completely neutralized by 54 cm^3 of a $0,05 \text{ mol} \cdot \text{dm}^{-3}$ H_2SO_4 solution. Calculate the concentration of the $Ba(OH)_2$ solution. (8)

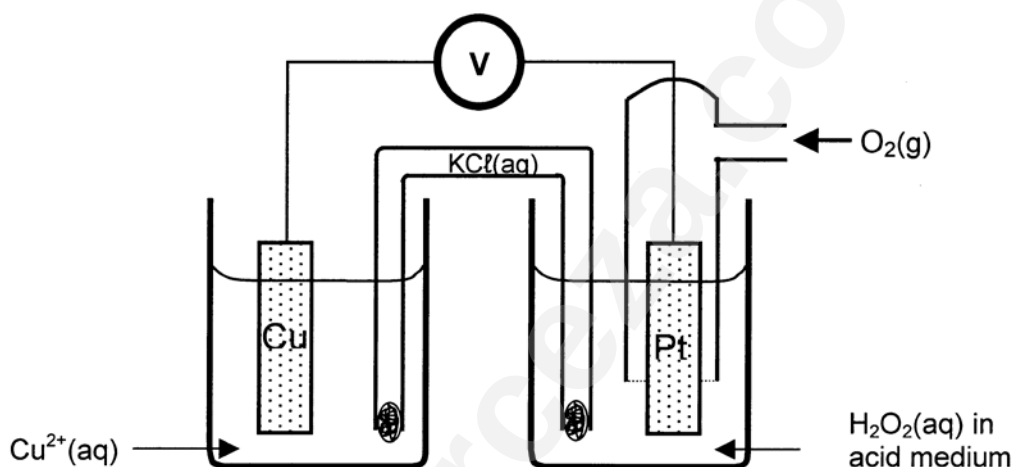
[17]

QUESTION 8 (Start on a new page.)

8.1 A group of learners set up a standard electrochemical cell using the following half – cells:



Potassium chloride (KCl) solution is used in the salt bridge.



8.1.1 Which electrode is the cathode? (1)

8.1.2 Write down the oxidation half-reaction. (2)

8.1.3 Write down the reduction half-reaction. (2)

8.1.4 Calculate the initial emf of the cell. (4)

8.2 A second group of learners set up another standard electrochemical cell using the following half-reactions:

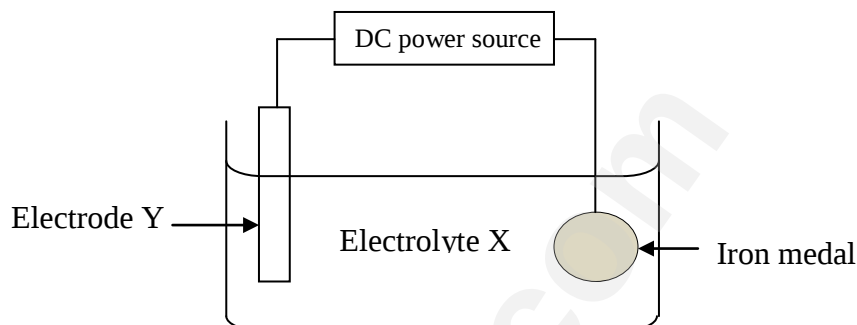


Write the balanced equation for the nett overall reaction. (3)

[12]

QUESTION 9 (Start on a new page.)

The simplified diagram below shows an electrolytic cell used at an electroplating company to coat iron medals with silver.

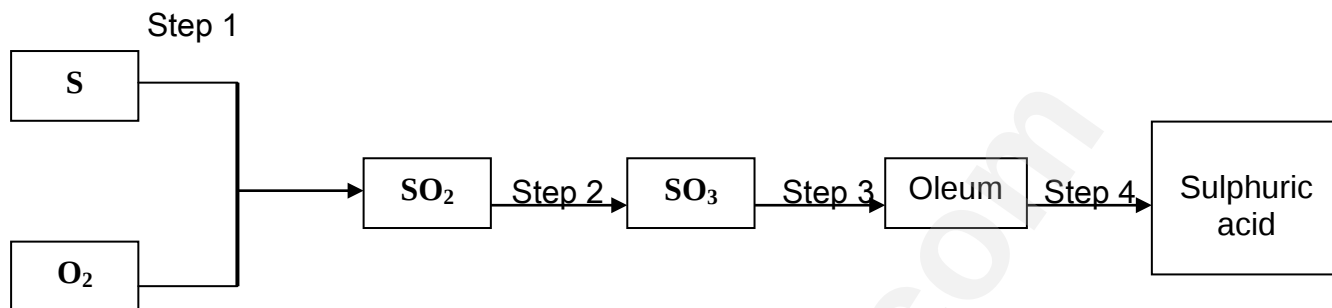


- 9.1 Write down the energy conversion that takes place in this cell. (1)
- 9.2 What physical change takes place at electrode Y when the cell is in operation? (2)
- 9.3 Which type of reaction (OXIDATION or REDUCTION) takes place at electrode Y? (1)
- 9.4 Write down the:
- 9.4.1 Equation for the half-reaction that takes place at the iron medal (2)
- 9.4.2 NAME or FORMULA of electrolyte X (1)
- 9.5 Give a reason why the concentration of electrolyte X remains constant during electroplating. (2)

[9]

QUESTION 10 (Start on a new page.)

10.1 Some of the steps in the industrial preparation of sulphuric acid are outlined below.

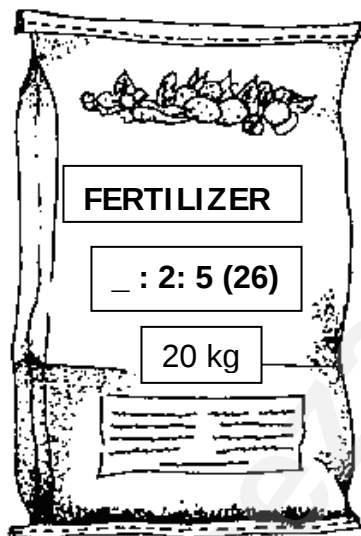


- 10.1.1 Write down a balanced equation for the reaction leading to the formation of SO_3 in Step 2. (2)
- 10.1.2 In which step is a catalyst used? (1)
- 10.1.3 Name the catalyst used. (1)

10.2 The rapidly increasing human population is resulting in an ever-increasing demand for food. To meet this demand, farmers apply fertiliser to the same cultivated land each year.

- 10.2.1 Explain why farmers have to apply fertiliser to the same land each year. (1)
- 10.2.2 Write down ONE negative impact that over-fertilisation can have on humans. (1)
- 10.2.3 What process occurs when excess fertilizers run into rivers? (1)
- 10.2.4 Write down the FORMULA of the fertiliser formed when sulphuric acid reacts with ammonia. (2)

- 10.3 Mr. Viljoen (a farmer) finds an old 20 kg bag of fertilizer. The label on the bag is only partially visible (see diagram below). He has the contents analysed and it is determined that the percentage of potassium in the bag is 13%.



10.3.1 What does the number (26) on the label represent?

(1)

10.3.2 Determine the unknown component in the N.P.K ratio

(4)

[14]

TOTAL MARKS: 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 <i>Standaarddruk</i>	p^θ	$1,013 \times 10^5 \text{ Pa}$
Molar gas volume at STP <i>Molêre gasvolume by STD</i>	V_m	$22,4 \text{ dm}^3 \cdot \text{mol}^{-1}$
Standard temperature <i>Standaardtemperatuur</i>	T^θ	273 K
Charge on electron <i>Lading op elektron</i>	e	$-1,6 \times 10^{-19} \text{ C}$
Avogadro's constant <i>Avogadro-konstante</i>	N_A	$6,02 \times 10^{23} \text{ mol}^{-1}$

TABLE 2: FORMULAE/TABEL 2: FORMULES

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/of $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$\text{pH} = -\log[\text{H}_3\text{O}^+]$
$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14} \text{ at/by } 298 \text{ K}$	
$E_{\text{cell}}^\theta = E_{\text{cathode}}^\theta - E_{\text{anode}}^\theta / E_{\text{sel}}^\theta = E_{\text{katode}}^\theta - E_{\text{anode}}^\theta$ or/of $E_{\text{cell}}^\theta = E_{\text{reduction}}^\theta - E_{\text{oxidation}}^\theta / E_{\text{sel}}^\theta = E_{\text{reduksie}}^\theta - E_{\text{oksidasie}}^\theta$ or/of $E_{\text{cell}}^\theta = E_{\text{oxidising agent}}^\theta - E_{\text{reducing agent}}^\theta / E_{\text{sel}}^\theta = E_{\text{oksideermiddel}}^\theta - E_{\text{reduseermiddel}}^\theta$	

KEY/SLEUTEL

Atomic number
Atoomgetal

Electronegativity

Symbol	Symbol
Cu	Cu
63,5	63,5

Approximate relative atomic mass
Benaderde relatiewe atoommassa

KEY/SLEUTEL												Atomic number	
Electronegativity												Atomgewicht	
Elektronenegativiteit												Elektronengetal	
1	H	1	2	He	4	4	10	Ne	20	20	20		
3	Li	5	7	B	11	12	14	O	16	16	16		
4	Be	9	11	C	12	14	15	N	14	14	14		
11	Na	12	14	Si	14	16	17	F	19	19	19		
23	Mg	24	26	Al	13	15	16	S	32	32	32		
19	K	20	22	Ca	20	22	24	Sc	21	21	21		
39	Y	40	42	Zr	40	42	44	Hf	72	72	72		
37	Rb	38	40	Sr	38	40	42	Y	39	39	39		
86	Cs	87	89	Ba	86	88	90	La	57	57	57		
133	Fr	134	136	Ra	133	135	137	Ac	89	89	89		
58	Ce	59	60	Pr	58	59	60	Nd	60	60	60		
62	Sm	63	64	Eu	62	63	64	Gd	64	64	64		
66	Dy	67	68	Ho	66	67	68	Er	68	68	68		
70	Yb	71	72	Lu	70	71	72	Tm	69	69	69		
80	Er	81	83	Yb	80	82	84	Lu	71	71	71		
88	Y	89	91	La	88	90	92	Pr	59	59	59		
92	U	94	96	Th	90	92	94	Pa	91	91	91		
100	Fm	101	103	Md	100	102	104	No	101	101	101		
108	Hf	109	111	Rf	108	110	112	Db	109	109	109		
116	Os	117	119	Hs	116	118	120	Uu	117	117	117		
124	Yb	125	127	Lu	124	126	128	Uu	125	125	125		
132	Uu	133	135	Uu	132	134	136	Uu	133	133	133		
140	Uu	141	143	Uu	140	142	144	Uu	141	141	141		
148	Uu	149	151	Uu	148	150	152	Uu	149	149	149		
156	Uu	157	159	Uu	156	158	160	Uu	157	157	157		
164	Uu	165	167	Uu	164	166	168	Uu	165	165	165		
172	Uu	173	175	Uu	172	174	176	Uu	173	173	173		
180	Uu	181	183	Uu	180	182	184	Uu	181	181	181		
188	Uu	189	191	Uu	188	190	192	Uu	189	189	189		
196	Uu	197	199	Uu	196	198	200	Uu	197	197	197		
204	Uu	205	207	Uu	204	206	208	Uu	205	205	205		
212	Uu	213	215	Uu	212	214	216	Uu	213	213	213		
220	Uu	221	223	Uu	220	222	224	Uu	221	221	221		
228	Uu	229	231	Uu	228	230	232	Uu	229	229	229		
236	Uu	237	239	Uu	236	238	240	Uu	237	237	237		
244	Uu	245	247	Uu	244	246	248	Uu	245	245	245		
252	Uu	253	255	Uu	252	254	256	Uu	253	253	253		
260	Uu	261	263	Uu	260	262	264	Uu	261	261	261		

[illegible]

TABLE 4A: STANDARD REDUCTION POTENTIALS

TABEL 4A: STANDAARD- REDUKSIEPOTENSIALE

Half-reactions/Halfreaksies	E° (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
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-$	+ 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
$Br_2(l) + 2e^- \rightleftharpoons 2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^- \rightleftharpoons NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^- \rightleftharpoons Hg(l)$	+ 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
$Al^{3+} + 3e^- \rightleftharpoons Al$	- 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 oxidising ability/Toenemende oksiderende vermoë

Increasing reducing ability/Toenemende reducerende vermoë

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

Half-reactions/Halfreaksies	E° (V)
$\text{Li}^{+} + \text{e}^{-} \rightleftharpoons \text{Li}$	-3,05
$\text{K}^{+} + \text{e}^{-} \rightleftharpoons \text{K}$	-2,93
$\text{Cs}^{+} + \text{e}^{-} \rightleftharpoons \text{Cs}$	-2,92
$\text{Ba}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Ba}$	-2,90
$\text{Sr}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Sr}$	-2,89
$\text{Ca}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Ca}$	-2,87
$\text{Na}^{+} + \text{e}^{-} \rightleftharpoons \text{Na}$	-2,71
$\text{Mg}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Mg}$	-2,36
$\text{Al}^{3+} + 3\text{e}^{-} \rightleftharpoons \text{Al}$	-1,66
$\text{Mn}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Mn}$	-1,18
$\text{Cr}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Cr}$	-0,91
$2\text{H}_2\text{O} + 2\text{e}^{-} \rightleftharpoons \text{H}_2(\text{g}) + 2\text{OH}^{-}$	-0,83
$\text{Zn}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Zn}$	-0,76
$\text{Cr}^{3+} + 3\text{e}^{-} \rightleftharpoons \text{Cr}$	-0,74
$\text{Fe}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Fe}$	-0,44
$\text{Cr}^{3+} + \text{e}^{-} \rightleftharpoons \text{Cr}^{2+}$	-0,41
$\text{Cd}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Cd}$	-0,40
$\text{Co}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Co}$	-0,28
$\text{Ni}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Ni}$	-0,27
$\text{Sn}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Sn}$	-0,14
$\text{Pb}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Pb}$	-0,13
$\text{Fe}^{3+} + 3\text{e}^{-} \rightleftharpoons \text{Fe}$	-0,06
$2\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{H}_2(\text{g})$	0,00
$\text{S} + 2\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{H}_2\text{S}(\text{g})$	+0,14
$\text{Sn}^{4+} + 2\text{e}^{-} \rightleftharpoons \text{Sn}^{2+}$	+0,15
$\text{Cu}^{2+} + \text{e}^{-} \rightleftharpoons \text{Cu}^{+}$	+0,16
$\text{SO}_4^{2-} + 4\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{SO}_2(\text{g}) + 2\text{H}_2\text{O}$	+0,17
$\text{Cu}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Cu}$	+0,34
$2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^{-} \rightleftharpoons 4\text{OH}^{-}$	+0,40
$\text{SO}_2 + 4\text{H}^{+} + 4\text{e}^{-} \rightleftharpoons \text{S} + 2\text{H}_2\text{O}$	+0,45
$\text{Cu}^{+} + \text{e}^{-} \rightleftharpoons \text{Cu}$	+0,52
$\text{I}_2 + 2\text{e}^{-} \rightleftharpoons 2\text{I}^{-}$	+0,54
$\text{O}_2(\text{g}) + 2\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{H}_2\text{O}_2$	+0,68
$\text{Fe}^{3+} + \text{e}^{-} \rightleftharpoons \text{Fe}^{2+}$	+0,77
$\text{NO}_3^{-} + 2\text{H}^{+} + \text{e}^{-} \rightleftharpoons \text{NO}_2(\text{g}) + \text{H}_2\text{O}$	+0,80
$\text{Ag}^{+} + \text{e}^{-} \rightleftharpoons \text{Ag}$	+0,80
$\text{Hg}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Hg}(\ell)$	+0,85
$\text{NO}_3^{-} + 4\text{H}^{+} + 3\text{e}^{-} \rightleftharpoons \text{NO}(\text{g}) + 2\text{H}_2\text{O}$	+0,96
$\text{Br}_2(\ell) + 2\text{e}^{-} \rightleftharpoons 2\text{Br}^{-}$	+1,07
$\text{Pt}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Pt}$	+1,20
$\text{MnO}_2 + 4\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{Mn}^{2+} + 2\text{H}_2\text{O}$	+1,23
$\text{O}_2(\text{g}) + 4\text{H}^{+} + 4\text{e}^{-} \rightleftharpoons 2\text{H}_2\text{O}$	+1,23
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^{+} + 6\text{e}^{-} \rightleftharpoons 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+1,33
$\text{Cl}_2(\text{g}) + 2\text{e}^{-} \rightleftharpoons 2\text{Cl}^{-}$	+1,36
$\text{MnO}_4^{-} + 8\text{H}^{+} + 5\text{e}^{-} \rightleftharpoons \text{Mn}^{2+} + 4\text{H}_2\text{O}$	+1,51
$\text{H}_2\text{O}_2 + 2\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons 2\text{H}_2\text{O}$	+1,77
$\text{Co}^{3+} + \text{e}^{-} \rightleftharpoons \text{Co}^{2+}$	+1,81
$\text{F}_2(\text{g}) + 2\text{e}^{-} \rightleftharpoons 2\text{F}^{-}$	+2,87

Increasing oxidising ability/Toenemende oksiderende vermoë

Increasing reducing ability/Toenemende reduserende vermoë