



# basic education

Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

**NATIONAL  
SENIOR CERTIFICATE**

**GRADE 12**

**PHYSICAL SCIENCES: CHEMISTRY (P2)**

**NOVEMBER 2011**

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



**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 the compound  $\text{CH}_3\text{Cl}$  belongs (1)
- 1.2 The general term that describes compounds that consist of hydrogen and carbon atoms only (1)
- 1.3 The stage reached in a reversible chemical reaction when the rate of the forward reaction is equal to the rate of the reverse reaction (1)
- 1.4 The name of the chemical substance in which  $\text{Al}_2\text{O}_3$  is dissolved to lower its melting point during the industrial extraction of aluminium (1)
- 1.5 The ability of a cell to store charge (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 general formulae represents alkynes?
- A  $\text{C}_n\text{H}_{2n+2}$
- B  $\text{C}_n\text{H}_{2n-2}$
- C  $\text{C}_n\text{H}_{2n}$
- D  $\text{C}_n\text{H}_{2n-1}$  (2)
- 2.2 Which ONE of the following homologous series does NOT contain a CARBONYL group ( $\text{C}=\text{O}$ )?
- A Aldehydes
- B Alcohols
- C Carboxylic acids
- D Esters (2)



2.3 The structures of four organic compounds are shown below.

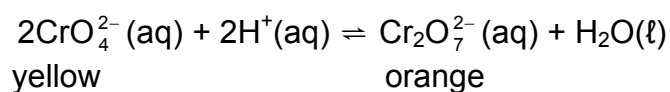
<b>I</b>	$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3 - \text{CH} - \text{CH} - \text{CH}_3 \\   \\ \text{OH} \end{array}$	<b>II</b>	$\begin{array}{c} \text{CH}_3 - \text{CH}_2 - \text{CH} - \text{OH} \\   \\ \text{CH}_2 \\   \\ \text{CH}_3 \end{array}$
<b>III</b>	$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH} - \text{CH}_3 \\   \quad   \\ \text{OH} \quad \text{CH}_3 \end{array}$	<b>IV</b>	$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{CH}_3 \\   \\ \text{CH}_2 \\   \\ \text{OH} \end{array}$

Which of the above compounds have the same IUPAC name?

- A I and II only
- B III and IV only
- C I and III only
- D II and IV only

(2)

2.4 The reaction represented by the equation below reaches equilibrium.



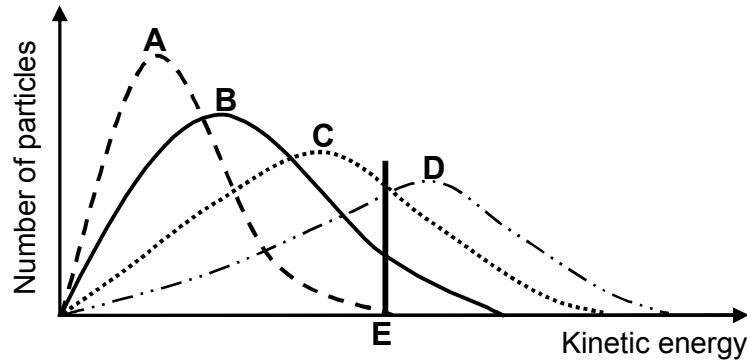
Which ONE of the following changes to the reaction mixture will change its colour from yellow to orange?

- A Add a catalyst.
- B Add water to the reaction mixture.
- C Add a few drops of sodium hydroxide solution to the reaction mixture.
- D Add a few drops of concentrated hydrochloric acid to the reaction mixture.

(2)



- 2.5 The Maxwell-Boltzmann energy distribution curves below show the number of particles as a function of their kinetic energy for a reaction at four different temperatures. The minimum kinetic energy needed for effective collisions to take place is represented by **E**.

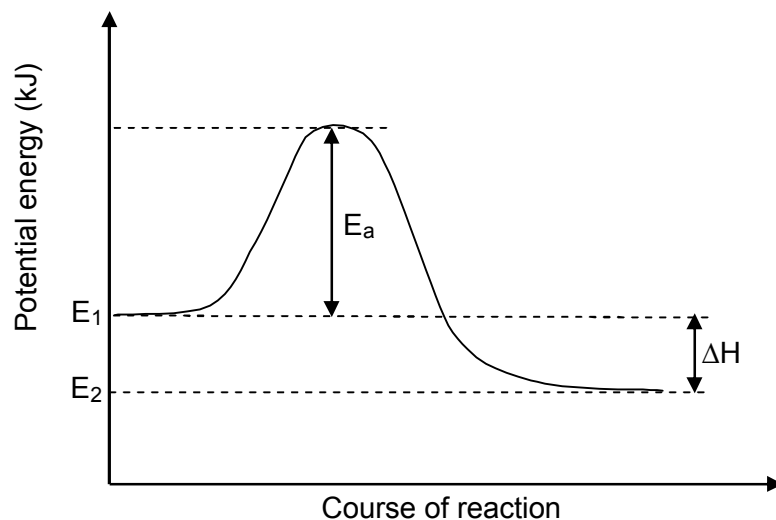


Which ONE of these curves represents the reaction with the highest rate?

- A A  
B B  
C C  
D D

(2)

- 2.6 A certain chemical reaction is represented by the potential energy diagram below.



Which ONE of the following quantities will change when a catalyst is added?

- A  $E_2$   
B  $E_1$   
C  $E_a$   
D  $\Delta H$

(2)



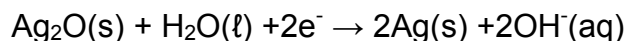
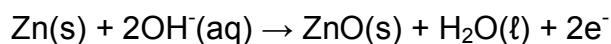
2.7 When a metallic atom becomes an ion, it ...

- A loses electrons and is oxidised.
- B loses electrons and is reduced.
- C gains electrons and is oxidised.
- D gains electrons and is reduced. (2)

2.8 Which ONE of the following substances CANNOT be used as a fertiliser?

- A Nitrogen gas
- B Guano
- C Bone meal
- D Ammonium sulphate (2)

2.9 Consider the two half-reactions below that occur in a battery.



Which ONE of the following statements is CORRECT?

- A Ag(s) is reduced.
- B Zn(s) is the anode.
- C Ag<sub>2</sub>O(s) is the negative electrode.
- D Electrons are transferred from Ag(s) to Zn(s). (2)

2.10 The oxidation number of copper (Cu) in the compound CuSO<sub>4</sub> is ...

- A - 2
  - B - 4
  - C + 2
  - D + 4 (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 final numerical answers to a minimum of TWO decimal places.

**QUESTION 3 (Start on a new page.)**

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

<b>A</b>	<b>B</b>
$  \begin{array}{ccccccccc}  & \text{H} & & \text{H} & & \text{H} & & \text{H} & & \text{O} \\  &   & &   & &   & &   & &    \\  \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\  &   & &   & &   & &   & & & \\  & \text{H} & & & & \text{H} & & \text{H} & & & \\  & & & & &   & & & & & \\  & & & & & \text{H} - \text{C} - \text{H} & & & & & \\  & & & & &   & & & & & \\  & & & & & \text{H} & & & & &   \end{array}  $	$  \begin{array}{ccccccc}  & & & & & \text{H} & \\  & & & & &   & \\  \text{H} & - \text{C} & \equiv & \text{C} & - & \text{C} & - \text{H} \\  & & & & &   & \\  & & & & & \text{H} &   \end{array}  $
<b>C</b>	<b>D</b>
$  \begin{array}{ccc}  \text{CH}_2 & \text{---} & \text{CH}_2 \\  & \diagdown & / \\  & & \text{CH}_2  \end{array}  $	$  \begin{array}{ccccccc}  & \text{H} & & \text{O} & & \text{H} & \\  &   & &    & &   & \\  \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\  &   & & & &   & \\  & \text{H} & & & & \text{H} &   \end{array}  $
<b>E</b>	<b>F</b>
$  \begin{array}{ccccccc}  & \text{H} & & \text{H} & & \text{H} & & \text{H} \\  &   & &   & &   & &   \\  \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\  &   & &   & &   & &   \\  & \text{H} & & \text{H} & & \text{H} & & \text{H}  \end{array}  $	ethyl butanoate

- 3.1 Write down the letter that represents the following:
- 3.1.1 A ketone (1)
  - 3.1.2 A compound which is an isomer of prop-1-ene (1)
- 3.2 Write down the IUPAC name of the following:
- 3.2.1 Compound **A** (2)
  - 3.2.2 Compound **B** (2)
- 3.3 Write down the NAME or FORMULA of EACH of the TWO products formed during the complete combustion of compound **E**. (2)

- 3.4 Compound **F** is the organic product of the reaction between a carboxylic acid and ethanol. Write down the following:
- 3.4.1 The name of the homologous series to which compound **F** belongs (1)
- 3.4.2 The structural formula of the FUNCTIONAL GROUP of carboxylic acids (1)
- 3.4.3 The IUPAC name of the carboxylic acid from which compound **F** is prepared (2)
- 3.4.4 The structural formula of compound **F** (2)
- [14]**

**QUESTION 4 (Start on a new page.)**

Three hydrocarbons (**A**, **B** and **C**) with molecular formula  $C_5H_{12}$  are used to investigate the effect of BRANCHING on the BOILING POINTS of hydrocarbons.

The results obtained are shown in the table below.

HYDROCARBON	BOILING POINT (°C)
<b>A</b>	36
<b>B</b>	28
<b>C</b>	10

- 4.1 Write down the term used to describe compounds with the same molecular formula, but with different structural formulae. (1)
- 4.2 Write down for this investigation the following:
- 4.2.1 Dependent variable (1)
- 4.2.2 Independent variable (1)
- 4.2.3 Controlled variable (1)
- 4.3 Are these hydrocarbons saturated or unsaturated? Explain the answer. (3)
- 4.4 One of the hydrocarbons (**A**, **B** or **C**) has a straight chain with no branches. Write down the following:
- 4.4.1 The letter (**A**, **B** or **C**) that represents this hydrocarbon (1)
- 4.4.2 Its IUPAC name (2)



4.5 Consider hydrocarbon **C** and its boiling point.

4.5.1 Write down the structural formula of hydrocarbon **C**. (2)

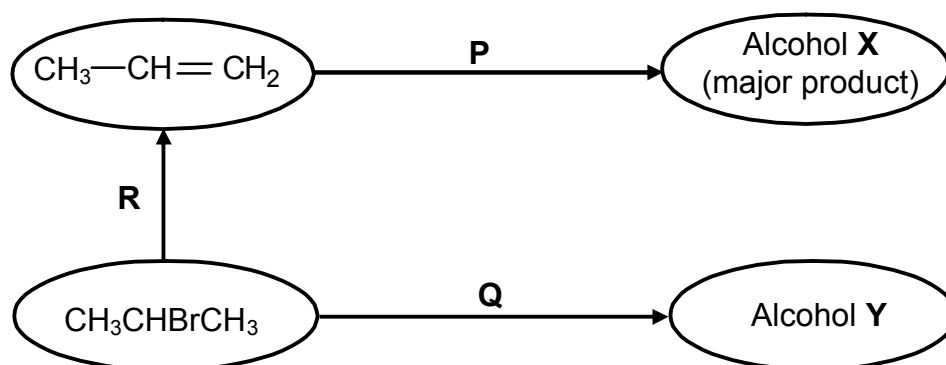
4.5.2 Explain why hydrocarbon **C** has the lowest boiling point. In your explanation, refer to its structure, intermolecular forces and the energy involved. (3)

4.6 Which ONE of hydrocarbons (**A**, **B** or **C**) has the highest vapour pressure? Refer to the data in the table to give a reason for the answer. (2)

[17]

**QUESTION 5 (Start on a new page.)**

In the flow diagram below **R**, **P** and **Q** represent different types of reactions.



5.1 Name the type of reaction represented by:

5.1.1 **P** (1)

5.1.2 **Q** (1)

5.1.3 **R** (1)

5.2 Using structural formulae, write down a balanced equation for reaction **P**. (4)

5.3 Write down the IUPAC name of alcohol **Y**. (2)

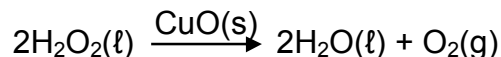
5.4 Reaction **Q** takes place in the presence of a BASE. Write down TWO reaction conditions for this reaction. (2)

[11]



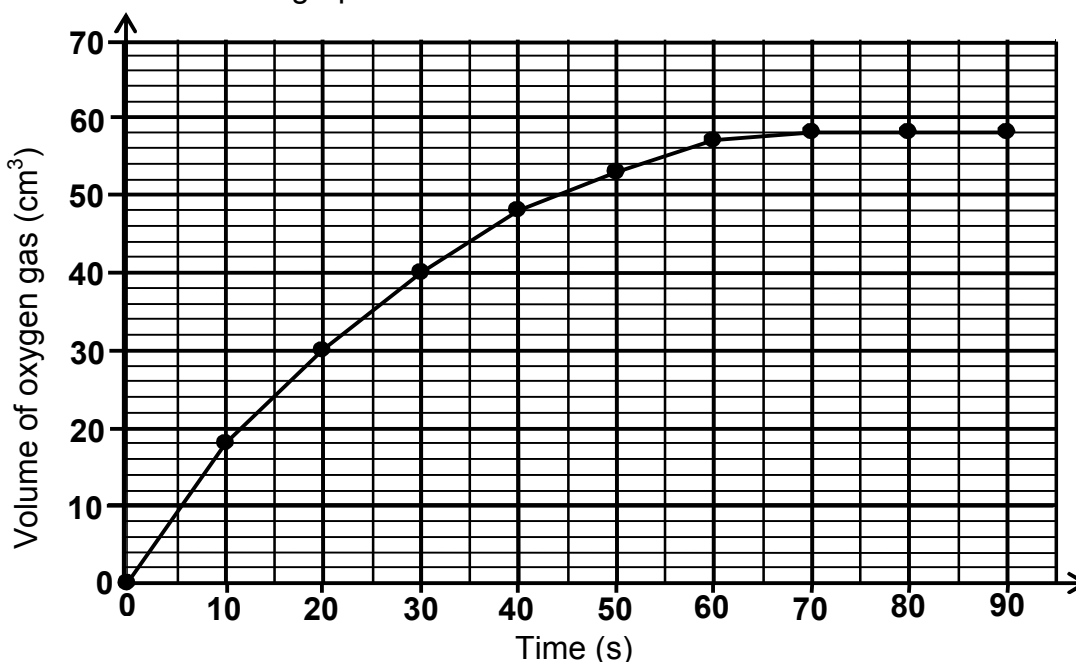
**QUESTION 6 (Start on a new page.)**

Learners use copper(II) oxide POWDER to decompose hydrogen peroxide. They add 1 g copper(II) oxide to 100 cm<sup>3</sup> hydrogen peroxide in a flask connected to a delivery tube. The reaction that takes place is represented by the following balanced equation:



- 6.1 Write down the name of ONE item of apparatus that can be used to measure the volume of the gas produced. (1)

The volume of oxygen gas produced is measured every 10 seconds. The results obtained are shown in the graph below.



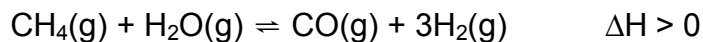
- 6.2 Use the graph to determine the volume of oxygen gas collected in the container at 15 seconds. (2)
- 6.3 How does the rate of the reaction change between  $t = 40$  s and  $t = 70$  s? Write down only INCREASES, DECREASES or REMAINS THE SAME. Refer to the graph to explain the answer. (2)
- 6.4 What is the function of the copper(II) oxide in this reaction? (1)
- 6.5 Apart from oxygen, write down the NAMES or FORMULAE of TWO substances present in the flask after 90 seconds. (2)
- 6.6 The learners found that oxygen is produced at a slower rate when 1 g of a SOLID LUMP of copper(II) oxide is used. Fully explain this observation. (2)
- 6.7 It is known that bad breath is due to bacterial activity in the mouth in the absence of oxygen.

Use the reaction above to explain why a solution containing hydrogen peroxide can be used as mouthwash to improve bad breath. (2)

**[12]**

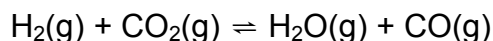
**QUESTION 7 (Start on a new page.)**

- 7.1 The industrial preparation of hydrogen gas is represented by the equation below.



The reaction reaches equilibrium at 1 000 °C in a closed container.

- 7.1.1 State Le Chatelier's principle. (3)
- 7.1.2 How will an increase in pressure at 1 000 °C (by decreasing the volume) affect the yield of hydrogen gas? Write down only INCREASES, DECREASES OR NO EFFECT. Explain the answer. (3)
- 7.1.3 Give TWO reasons why high temperatures are used for this reaction. (2)
- 7.2 Study the reversible reaction represented by the balanced equation below.



Initially  $x$  moles of  $\text{H}_2(\text{g})$  is mixed with 0,3 moles of  $\text{CO}_2(\text{g})$  in a sealed 10 dm<sup>3</sup> container. When equilibrium is reached at a certain temperature, it is found that 0,2 moles of  $\text{H}_2\text{O}(\text{g})$  is present.

The equilibrium constant ( $K_c$ ) for the reaction at this temperature is 4.

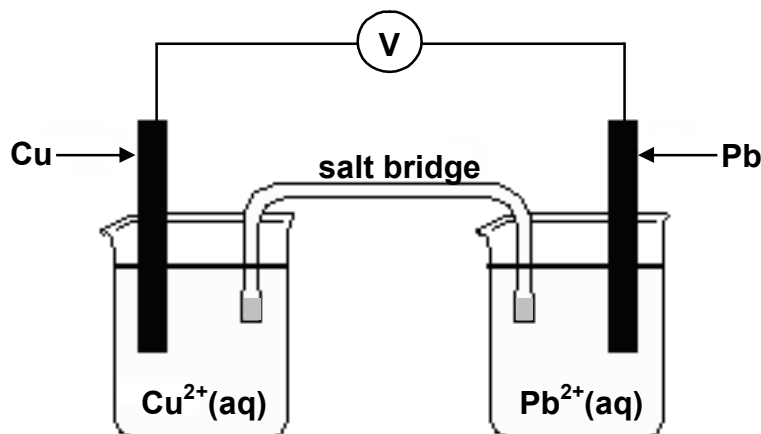
- 7.2.1 Calculate the initial number of moles of  $\text{H}_2(\text{g})$ ,  $x$ , that was in the container. (8)
- 7.2.2 The reaction is now carried out at a much higher temperature. It is found that  $K_c$  decreases at this higher temperature.
- Is this reaction exothermic or endothermic? Explain the answer. (3)

**[19]**

**QUESTION 8 (Start on a new page.)**

The potential difference of a galvanic cell, measured experimentally by learners, is COMPARED with its potential difference calculated at standard conditions.

They set up the galvanic cell shown below.



The voltmeter measures an initial reading of 0,3 V.

- 8.1 Write down the energy conversion that takes place in this cell. (1)
- 8.2 State ONE function of the salt bridge. (1)
- 8.3 Write down the half-reaction that takes place at the anode. (2)
- 8.4 In which direction do electrons flow in the external circuit when this cell delivers a current? Write down only 'from Cu to Pb' or 'from Pb to Cu'. (1)
- 8.5 Write down the balanced net (overall) cell reaction. (3)
- 8.6 Is the cell reaction exothermic or endothermic? (1)
- 8.7 Use the Table of Standard Reduction Potentials to calculate the initial potential difference (emf) of the above cell at STANDARD CONDITIONS. (4)
- 8.8 From the results obtained the learners conclude that the measured potential difference differs from the calculated potential difference. (4)

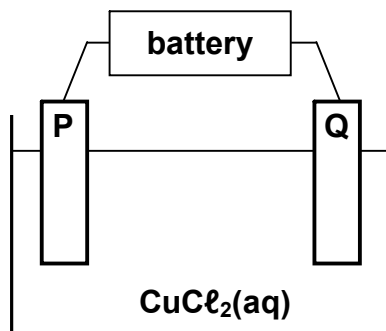
Give TWO possible reasons for this difference in values.

(4)  
[17]



**QUESTION 9 (Start on a new page.)**

In the electrolytic cell, represented below, two CARBON RODS are used as electrodes and a concentrated copper(II) chloride solution is used as electrolyte.



When the cell is functioning, a gas is released at electrode **P**, whilst electrode **Q** is coated with a reddish brown layer.

9.1 Define the term *electrolyte*. (2)

9.2 Write down a half-reaction to explain the observation made at:

9.2.1 Electrode **P** (2)

9.2.2 Electrode **Q** (2)

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

9.4 The carbon rods in the above cell are now replaced with COPPER RODS.

The following observations are made at electrode **P**:

- No gas is released.
- Its surface appears rough and eroded.

9.4.1 Refer to the RELATIVE STRENGTHS OF REDUCING AGENTS to explain this observation. (3)

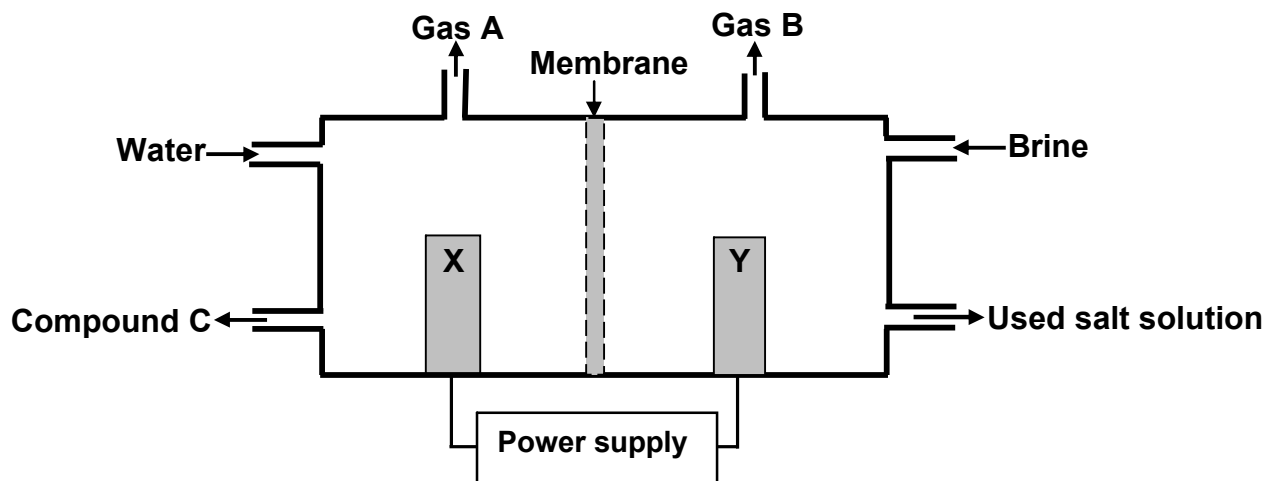
9.4.2 This cell can be used for the refining of copper. Which electrode (**P** or **Q**) will be replaced with impure copper during the refining process? (1)

**[12]**



**QUESTION 10 (Start on a new page.)**

The simplified diagram of a membrane cell used in the chlor-alkali industry is shown below. Gas **A**, gas **B** and compound **C** are the three major products formed during this process. **X** and **Y** represent the two electrodes.



- 10.1 Write down the function of the membrane in this cell. (1)
- 10.2 Which electrode, **X** or **Y**, is connected to the positive terminal of the power supply? Briefly explain how you arrived at the answer. (2)
- 10.3 Write down the NAME or FORMULA of:
- 10.3.1 Gas **A** (1)
- 10.3.2 Gas **B** (1)
- 10.3.3 Compound **C** (1)
- 10.4 Write down the balanced net (overall) cell reaction taking place in this cell. (3)
- 10.5 The chlor-alkali industry is sometimes blamed for contributing to the greenhouse effect. Briefly explain how the above cell contributes to the greenhouse effect. (2)

**[11]**

**QUESTION 11 (Start on a new page.)**

Nitric acid is used in the preparation of fertiliser. The flow diagram below shows the three steps (A, B and C) in the industrial preparation of nitric acid.



- 11.1 Write down the following:
- 11.1.1 Name of this industrial process in the preparation of nitric acid (1)
- 11.1.2 Balanced equation for step B (3)
- 11.2  $\text{NH}_3(\text{g})$  reacts with  $\text{O}_2(\text{g})$  to form two products in step A. One of the products is nitrogen(II) oxide. Write down the NAME or FORMULA of the OTHER product. (1)
- 11.3 In step C, water is added to the reaction mixture. This step can be represented by the following incomplete equation:
- $$\text{NO}_2(\text{g}) + \underline{\hspace{1cm}} + \text{H}_2\text{O}(\ell) \rightarrow \text{HNO}_3(\ell)$$
- Copy the above incomplete equation into your ANSWER BOOK, fill in the missing reactant and balance the equation. (2)
- 11.4 A 50 kg bag of fertiliser is labelled as shown in the diagram below.



- Calculate the mass of nitrogen present in this bag of fertiliser. (3)
- 11.5 Uncontrolled use of fertiliser may cause excess fertiliser to run down into streams and rivers, leading to eutrophication.
- State ONE negative impact that eutrophication in water may have on humans. (2)

**TOTAL SECTION B: 125**  
**GRAND TOTAL: 150**



**DATA FOR PHYSICAL SCIENCES GRADE 12  
PAPER 2 (CHEMISTRY)**

**GEGEWENS VIR FISIESTE WETENSKAPPE GRAAD 12  
VRAESTEL 2 (CHEMIE)**

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

NAME/NAAM	SYMBOL/SIMBOOL	VALUE/WAARDE
Standard pressure <i>Standaarddruk</i>	$p^{\theta}$	$1,013 \times 10^5 \text{ Pa}$
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>	$T^{\theta}$	273 K
Charge on electron <i>Lading op elektron</i>	$e$	$-1,6 \times 10^{-19} \text{ C}$

**TABLE 2: FORMULAE/TABEL 2: FORMULES**

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





NSC

TABLE 3: THE PERIODIC TABLE OF ELEMENTS  
 TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

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

KEY/SLEUTEL

Atomic number  
Atoomgetal

Electronegativity  
Elektronegatiwiteit

Symbol  
Simbool

Approximate relative atomic mass  
Benaderde relatiewe atoommassa

29  
 1,9  
**Cu**  
 63,5



NSC

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

Half-reactions/ <i>Halfreaksies</i>	$E^{\theta}$ (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
<b><math>2H^+ + 2e^- \rightleftharpoons H_2(g)</math></b>	<b>0,00</b>
$Fe^{3+} + 3e^- \rightleftharpoons Fe$	- 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 reduserende vermoë*



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

Increasing oxidising ability/Toenemende oksiderende vermoë

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

Increasing reducing ability/Toenemende reduserende vermoë

