basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL
SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

NOVEMBER 2017

MARKS: 150

TIME: 3 hours

This question paper consists of 16 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.   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

Various options are provided as possible answers to the following questions. 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 D.

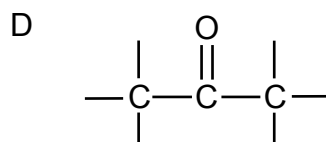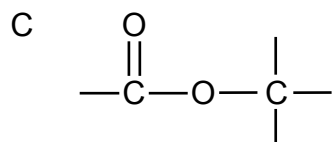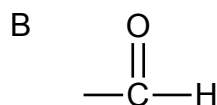1.1   The IUPAC name of an organic compound with molecular formula $C_7H_{14}O_2$:

    A   Heptanal

    B   Heptan-1-ol

    C   Heptan-2-ol

    D   Heptanoic acid   (2)

1.2   Which ONE of the following structures is the functional group of aldehydes?
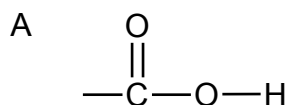
    (2)

1.3   Which ONE of the following equations represents a cracking process?

    A $5CH_2 = CH_2 \rightarrow -(CH_2CH_2)_5-$

    B $CH_3(CH_2)_5CH = CH_2 + H_2 \rightarrow CH_3(CH_2)_6CH_3$

    C $CH_3(CH_2)_6CH_3 \rightarrow CH_3(CH_2)_4CH_3 + CH_2 = CH_2$
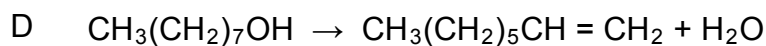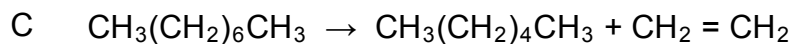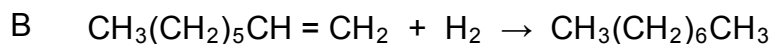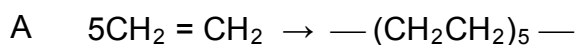
    D $CH_3(CH_2)_7OH \rightarrow CH_3(CH_2)_5CH = CH_2 + H_2O$ (2)

1.4   The potential energy diagram for a chemical reaction is shown below.
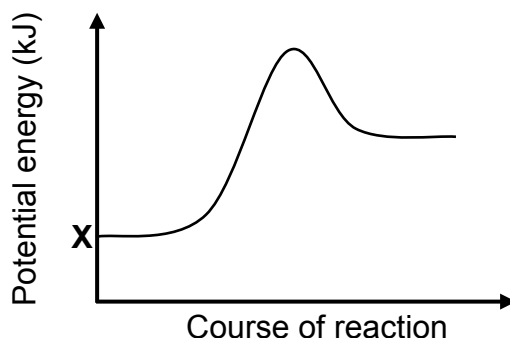
Consider the following statements regarding the graph above:

I: **X** represents the potential energy of the products formed during the reverse reaction.

II: The graph could be a representation of the change in potential energy for the following reaction:

$$CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq) \quad \Delta H > 0$$

III: The graph could be a representation of the change in potential energy for the combustion of methane.

Which of the statements above are TRUE?

A   **I** and **II** only

B   **II** and **III** only

C   **I** and **III** only

D   **I**, **II** and **III**   (2)

1.5   A certain chemical reaction reaches equilibrium at 25 °C. The equilibrium constant, K_c, for the reaction at this temperature is $1,0 \times 10^{-4}$.

Which ONE of the following statements regarding this reaction at equilibrium is CORRECT?

A   The concentration of the products is equal to that of the reactants.

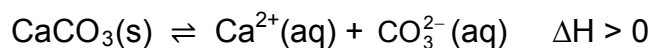B   The concentration of the products is higher than that of the reactants.

C   The concentration of the products is lower than that of the reactants.

D   The rate of the forward reaction is lower than the rate of the reverse reaction.   (2)

1.6   Consider the following chemical reaction at equilibrium in a closed container:

$$2HgO(s) \rightleftharpoons 2Hg(\ell) + O_2(g)$$
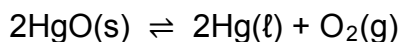
More HgO(s) is now added to the container at constant temperature.

How will the number (in moles) of $O_2(g)$ and the value of K_c be affected at equilibrium?

	NUMBER OF MOLES OF O_2	K_c
A	Increases	Increases
B	Increases	Remains the same
C	Remains the same	Remains the same
D	Remains the same	Increases

(2)

1.7   Which ONE of the following solutions, each of concentration 0,1 mol·dm^{-3}, has the highest pH?

A $HNO_3(aq)$

B $NH_4C\ell(aq)$

C $Na_2CO_3(aq)$

D $CH_3COOH(aq)$ (2)

1.8   The cell notation for a galvanic cell is as follows:

$$Ni(s) \mid Ni^{2+} (1 \text{ mol·dm}^{-3}) \parallel Pb^{2+} (1 \text{ mol·dm}^{-3}) \mid Pb(s)$$

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

A   Ni is oxidised.

B   Pb(s) is reduced.

C $Ni^{2+}(aq)$ is the oxidising agent.

D Pb^{2+} is the reducing agent.   (2)

1.9   Which ONE of the following combinations CORRECTLY shows the products formed during the electrolysis of a CONCENTRATED sodium chloride solution?

	CATHODE	ANODE
A	Hydrogen	Sodium
B	Hydrogen	Chlorine
C	Chlorine	Sodium
D	Chlorine	Hydrogen

(2)

1.10   Which ONE of the following is NOT part of the eutrophication process?

A   Algal bloom

B   Bacterial nitrogen fixation

C   Depletion of oxygen in water

D   Increase in plant nutrients in water   (2)
[20]

QUESTION 2 (Start on a new page.)

2.1 Study the structural formula below.
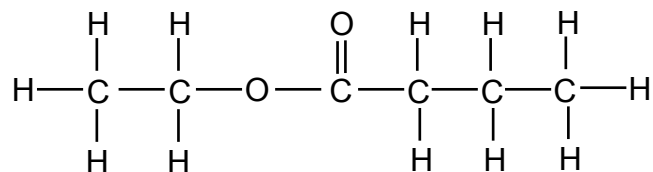
For this compound, write down the:

2.1.1 Homologous series to which it belongs (1)

2.1.2 IUPAC name (2)

2.1.3 IUPAC name of the organic acid used in its preparation (1)

2.1.4 STRUCTURAL FORMULA of its straight chain (unbranched) functional isomer (2)

2.2 Write down the structural formula of 4-methylpentan-2-one. (3)

2.3 Consider the structural formula below.

For this compound, write down the:

2.3.1 General formula of the homologous series to which it belongs (1)

2.3.2 IUPAC name (3)

[13]

QUESTION 3 (Start on a new page.)

The vapour pressure versus temperature graph below was obtained for four straight chain (unbranched) alkanes (**P**, **Q**, **R** and **S**).
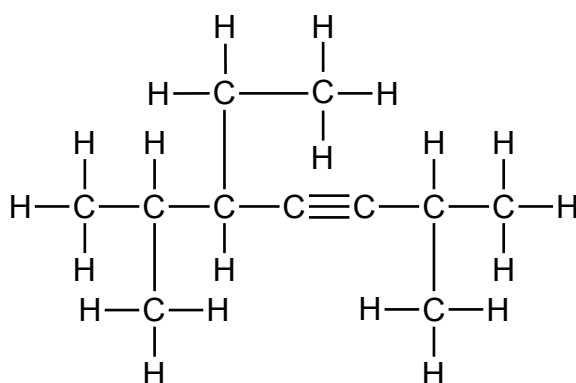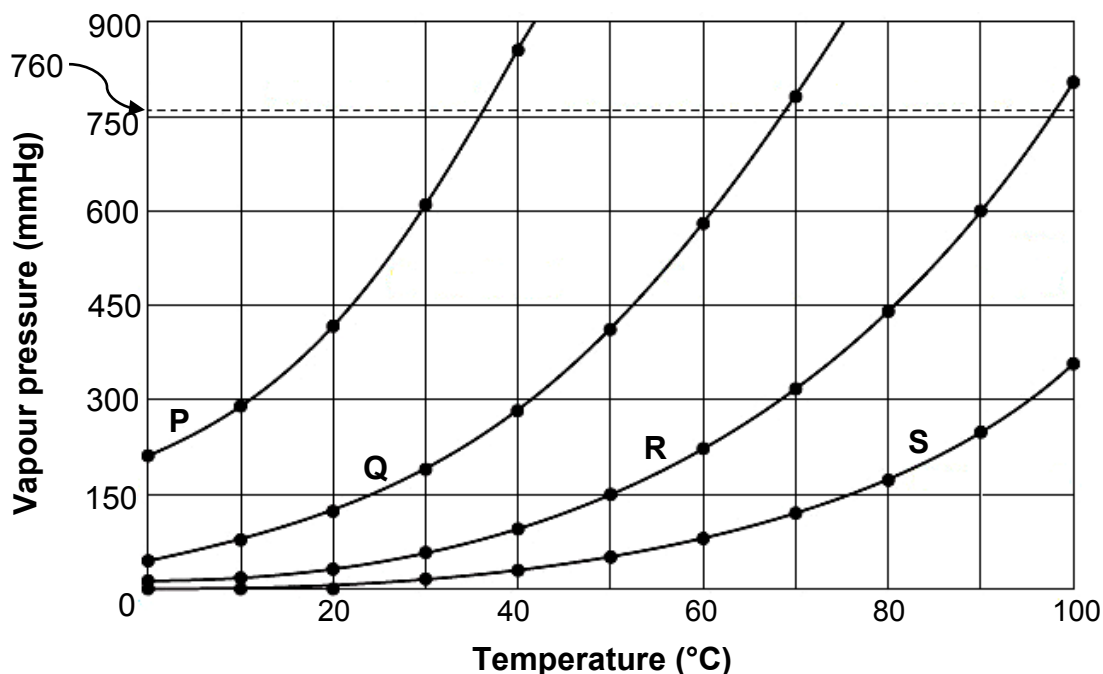
FROM **P** TO **S**, EACH COMPOUND DIFFERS FROM THE PREVIOUS COMPOUND BY A $-CH_2$ GROUP.

The vapour pressures are measured in mmHg. Atmospheric pressure is 760 mmHg.

Graph of vapour pressure versus temperature

3.1   Give a reason why alkanes are said to be SATURATED.   (1)

3.2   Define *vapour pressure.*   (2)

3.3   Use the information in the graph above to answer the following questions.

      3.3.1   What is the effect of an increase in temperature on vapour pressure? Choose from INCREASES, DECREASES or NO EFFECT.   (1)

      3.3.2   Which compound has a boiling point of approximately 68 °C? Give a reason for the answer.   (2)

      3.3.3   Which compound has the longest chain length? Fully explain the answer.   (4)

3.4   Compound **P** has FIVE carbon atoms.

      3.4.1   Draw the structural formula of a chain isomer of **P**. Write down the IUPAC name of this isomer.   (3)

      3.4.2   How will the vapour pressure of this isomer compare with that of compound **P**? Choose from HIGHER THAN, LOWER THAN or EQUAL TO.   (1)

[14]

QUESTION 4 (Start on a new page.)

The flow diagram below shows how an alcohol (compound **P**) can be used to prepare other organic compounds. The letters **A** to **E** represent different organic reactions. **X**, **Y** and **Z** are organic compounds.
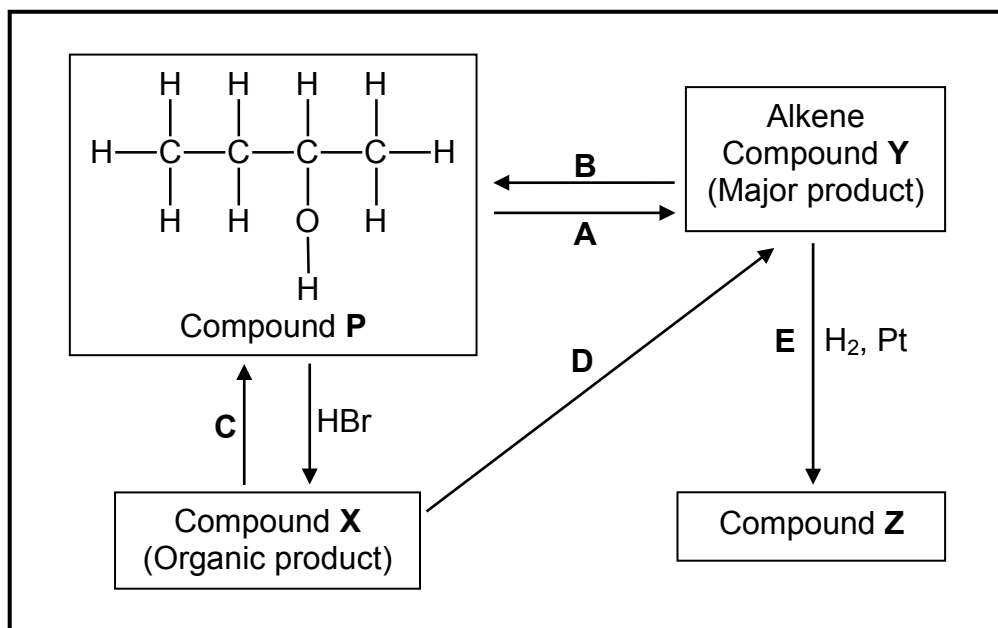
4.1   Is compound **P** a PRIMARY, SECONDARY or TERTIARY alcohol? Give a reason for the answer.   (2)

4.2   Write down the type of:

         4.2.1   Elimination reaction represented by **A**   (1)

         4.2.2   Addition reaction represented by **B**   (1)

         4.2.3   Elimination reaction represented by **D**   (1)

4.3   Sodium hydroxide is used as one of the reactants in reaction **C**.

         4.3.1   What type of reaction takes place here?   (1)

         4.3.2   State the TWO reaction conditions for this reaction.   (2)

         4.3.3   Write down the IUPAC name of compound **X**.   (2)

4.4   Write down the FORMULA of an inorganic reactant needed for reaction **D**.   (1)

4.5   Using STRUCTURAL FORMULAE, write down a balanced equation for reaction **E**.   (3)

4.6   Write down the IUPAC name of compound **Z**.   (1)

         [15]

QUESTION 5 (Start on a new page.)

A group of learners uses the reaction between powdered zinc and EXCESS dilute hydrochloric acid to investigate one of the factors that affects the rate of a chemical reaction. The balanced equation for the reaction is:

$$Zn(s) + 2HC\ell(aq) \rightarrow ZnC\ell_2(aq) + H_2(g)$$
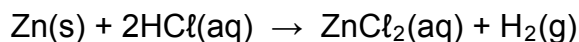
They conduct two experiments. The reaction conditions used are summarised in the table below.

EXPERIMENT	TEMPERATURE (°C)	VOLUME OF HCℓ (cm³)	CONCENTRATION OF HCℓ (mol·dm⁻³)	MASS OF Zn (g)
I	25	200	0,25	x
II	25	200	0,40	x

The results obtained are shown in the graph (not drawn to scale) below.

Graph of volume of H₂(g) produced versus time
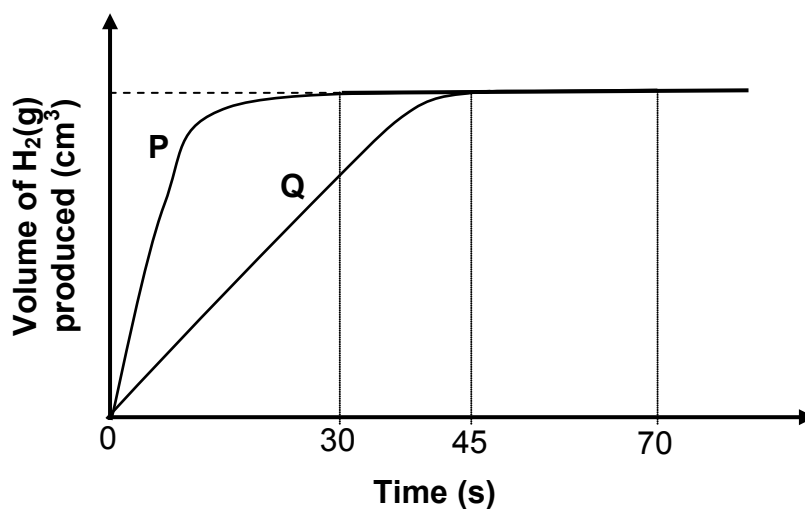
5.1   Define *reaction rate*. (2)

5.2   Write down an investigative question for this investigation. (2)

5.3   Which curve, **P** or **Q**, represents the results of experiment **I**? Explain the answer. (3)

5.4   The average rate of the production of hydrogen gas, as represented by graph **P**, was 15 cm³·s⁻¹. Calculate the mass of zinc used. **Take the molar gas volume at 25 °C as 24 000 cm³**. (5)

5.5 In a third experiment (experiment **III**), 200 cm^3 of a 0,25 mol·dm^{-3} dilute hydrochloric acid solution at 35 °C reacts with the same amount of zinc powder as in experiment **I** and experiment **II**.

    5.5.1 How will the heat of reaction of experiment **II** compare with that of experiment **III**? Choose from MORE THAN, LESS THAN or EQUAL TO. (1)

    5.5.2 How will the activation energy of the reaction in experiment **I** compare with that of the reaction in experiment **III**? Choose from MORE THAN, LESS THAN or EQUAL TO. (1)

5.6 The rate of the reaction in experiment **III** is higher than that of experiment **I**.

    Fully explain this statement by referring to the collision theory. (3)

[17]

QUESTION 6 (Start on a new page.)

Carbonyl bromide, $COBr_2$, decomposes into carbon monoxide and bromine according to the following balanced equation:

$$COBr_2(g) \rightleftharpoons CO(g) + Br_2(g) \qquad \Delta H > 0$$
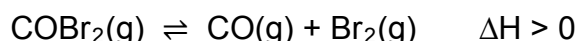
Initially $COBr_2(g)$ is sealed in a 2 dm^3 container and heated to 73 °C. The reaction is allowed to reach equilibrium at this temperature. The equilibrium constant for the reaction at this temperature is 0,19.

6.1 Define *chemical equilibrium*. (2)

At equilibrium it is found that 1,12 g $CO(g)$ is present in the container.

6.2 Calculate the:

    6.2.1 Equilibrium concentration of the $COBr_2(g)$ (7)

    6.2.2 Percentage of $COBr_2(g)$ that decomposed at 73 °C (4)

6.3 Which ONE of the following CORRECTLY describes the K_c value when equilibrium is reached at a lower temperature?

| $K_c < 0,19$	$K_c > 0,19$	$K_c = 0,19$

(1)

6.4 The pressure of the system is now decreased by increasing the volume of the container at 73 °C and the system is allowed to reach equilibrium.

    How will the number of moles of $COBr_2(g)$ be affected? Choose from INCREASES, DECREASES or REMAINS THE SAME. Explain the answer. (3)

[17]

QUESTION 7 (Start on a new page.)

7.1   Ammonia ionises in water to form a basic solution according to the following balanced equation:

$$NH_3(g) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$
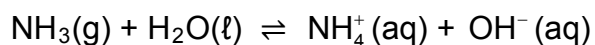
      7.1.1   Is ammonia a WEAK or a STRONG base? Give a reason for the answer.   (2)

      7.1.2   Write down the conjugate acid of $NH_3(g)$.   (1)

      7.1.3   Identify ONE substance in this reaction that can behave as an ampholyte in some reactions.   (1)

7.2   A learner adds distilled water to a soil sample and then filters the mixture. The pH of the filtered liquid is then measured.

He then gradually adds an ammonia solution, $NH_3(aq)$, to this liquid and measures the pH of the solution at regular intervals. The graph below shows the results obtained.

Graph of pH versus volume of $NH_3(aq)$
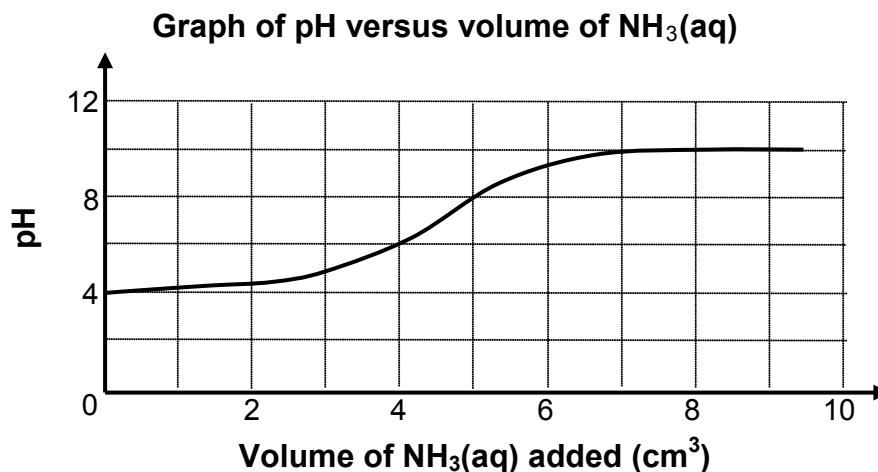
      7.2.1   Is the soil sample ACIDIC or BASIC? Refer to the graph above and give a reason for the answer.   (2)

      7.2.2   Calculate the concentration of the hydroxide ions (OH^-) in the reaction mixture after the addition of 4 cm^3 of $NH_3(aq)$.   (4)

7.3   A laboratory technician wants to determine the concentration of a hydrochloric acid (HCℓ) sample. He adds 5 cm³ of the HCℓ sample to 495 cm³ of distilled water to give 500 cm³ of dilute hydrochloric acid, HCℓ(aq).

During a reaction 50 cm³ of this dilute hydrochloric acid solution, HCℓ(aq), reacts completely with 0,29 g of sodium carbonate, Na_2CO_3(s).

5 cm³   50 cm³

HCℓ sample   495 cm³ distilled water   0,29 g Na_2CO_3

The balanced equation for the reaction is:

$$Na_2CO_3(s) + 2HCℓ(aq) \rightarrow 2NaCℓ(aq) + CO_2(g) + H_2O(ℓ)$$
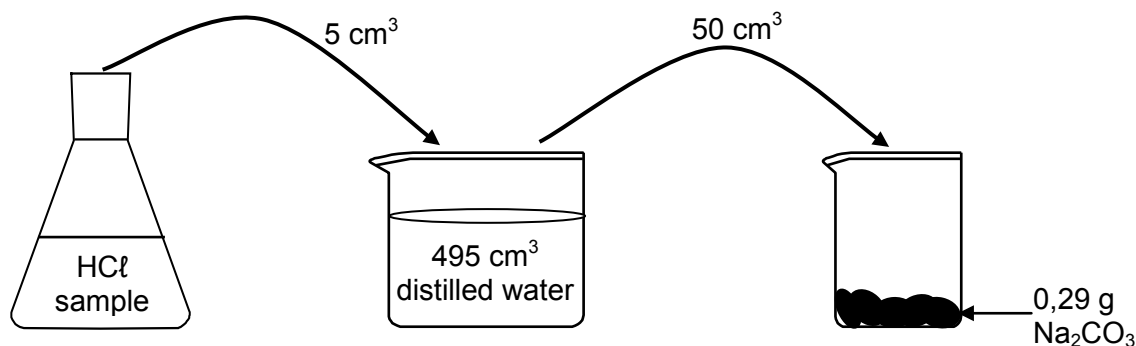
Calculate the concentration of the hydrochloric acid sample.   (7)

[17]

QUESTION 8 (Start on a new page.)

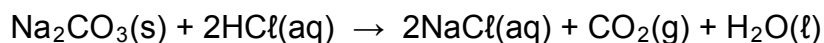8.1   Learners set up a galvanic cell and measure its emf under standard conditions.

Y

Aℓ   Ag

AgNO₃(aq)
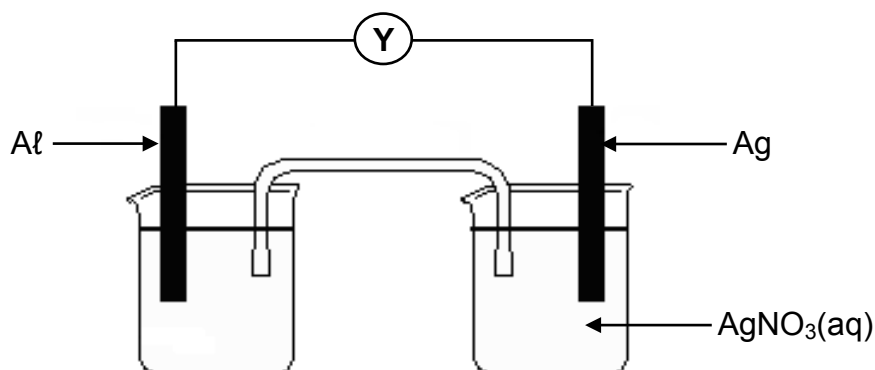
8.1.1   Write down the name of component **Y**.   (1)

8.1.2   Is Aℓ the ANODE or the CATHODE?   (1)

8.1.3   Write down the overall (net) cell reaction that takes place in this cell when it is working.   (3)

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

8.2   Consider the half-cells, **P**, **Q** and **R**, represented in the table below.

HALF-CELL		
P	**Q**	**R**
$Zn \mid Zn^{2+}(aq)$	$C\ell_2 \mid C\ell^-(aq)$	$Cu \mid Cu^{2+}(aq)$

Different combinations of the half-cells above are compared to determine the highest emf produced under standard conditions.

8.2.1   Write down the NAME of a suitable electrode for half-cell **Q**.   (1)

8.2.2   State the standard conditions under which the half-cells should operate to ensure a fair comparison.   (2)

8.2.3   Write down the NAME or FORMULA of the strongest reducing agent in the half-cells above.   (1)

8.2.4   Which combination of half-cells will produce the highest emf? Choose from **PR**, **PQ** or **QR**. (NO calculation is required.)   (1)

[14]

QUESTION 9 (Start on a new page.)

The simplified diagram below represents an electrochemical cell used in the refining of copper. One of the electrodes consists of impure copper.

Concentrated
$CuCl_2(aq)$
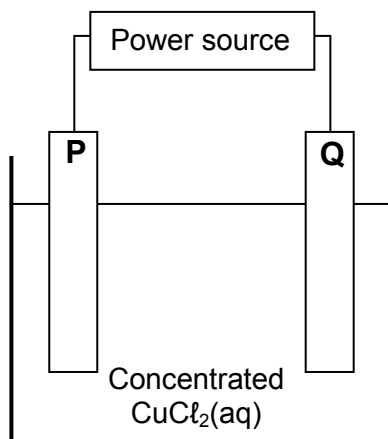
9.1   What type of power source, AC or DC, is used to drive the reaction in this cell?   (1)

9.2   When an electric current passes through the $CuCl_2(aq)$, the mass of electrode **P** increases.

Is electrode **P** the CATHODE or the ANODE?
Write down the relevant half-reaction to support the answer.   (3)

9.3   The impure copper contains zinc impurities which are oxidised to zinc ions.

Refer to the relative strengths of oxidising agents to explain why zinc ions will not influence the quality of the pure copper produced in this cell.   (3)

9.4   Electrodes **P** and **Q** are now replaced by carbon electrodes.

9.4.1   What will be observed at electrode **Q**?   (1)

9.4.2   How will the concentration of the electrolyte change as the reaction proceeds? Choose from INCREASES, DECREASES or REMAINS THE SAME.   (1)

[9]

QUESTION 10 (Start on a new page.)

10.1   The equations below represent two industrial processes involved in the preparation of ammonium nitrate.

Process X	**Process Y**
I: $A + 5O_2(g) \rightarrow 4NO + 6H_2O(g)$ **II:** $2NO(g) + O_2(g) \rightarrow 2B$ **III:** $B + H_2O(g) \rightarrow HNO_3(g) + NO(g)$	**IV:** $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

Ammonium nitrate
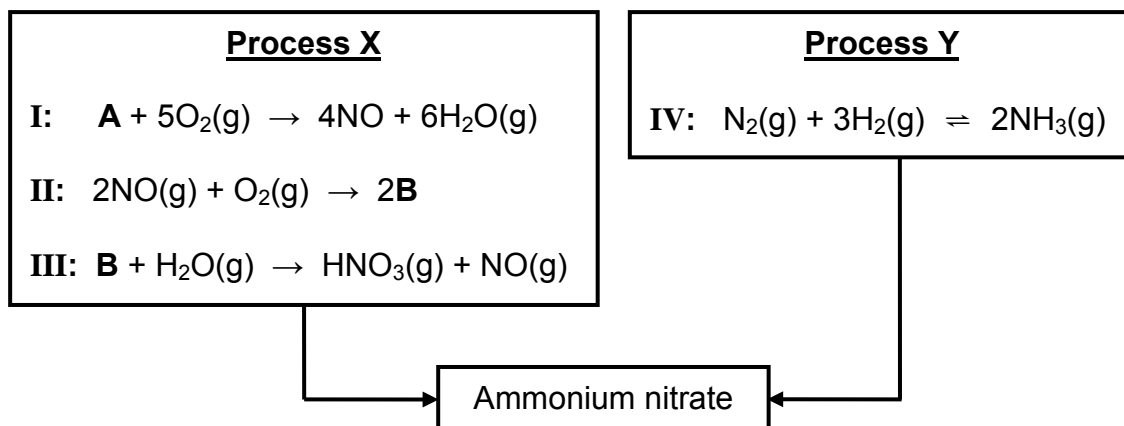
Write down the:

10.1.1   NAME of substance **A**   (1)

10.1.2   FORMULA of substance **B**   (1)

10.1.3   NAME given for reaction **I**   (1)

10.1.4   NAME or FORMULA of the catalyst used in reaction **I**   (1)

10.1.5   Name of process **X**   (1)

10.1.6   Name of process **Y**   (1)

10.1.7   Balanced equation for the preparation of ammonium nitrate from the products obtained in process **X** and process **Y**   (3)

10.2   A 15 kg bag of fertiliser contains 5% phosphorus, 10% nitrogen and 15% potassium.

Calculate the:

10.2.1   Mass of phosphorus in the bag   (2)

10.2.2   Mass of filler in the bag   (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*

$n = \dfrac{m}{M}$	$n = \dfrac{N}{N_A}$
$c = \dfrac{n}{V}$ or/*of* $c = \dfrac{m}{MV}$	$n = \dfrac{V}{V_m}$
$\dfrac{c_a v_a}{c_b v_b} = \dfrac{n_a}{n_b}$	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
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 **H** 2,1 1																	2 **He** 4
3 **Li** 1,0 7	4 **Be** 1,5 9											5 **B** 2,0 11	6 **C** 2,5 12	7 **N** 3,0 14	8 **O** 3,5 16	9 **F** 4,0 19	10 **Ne** 20
11 **Na** 0,9 23	12 **Mg** 1,2 24											13 **Aℓ** 1,5 27	14 **Si** 1,8 28	15 **P** 2,1 31	16 **S** 2,5 32	17 **Cℓ** 3,0 35,5	18 **Ar** 40
19 **K** 0,8 39	20 **Ca** 1,0 40	21 **Sc** 1,3 45	22 **Ti** 1,5 48	23 **V** 1,6 51	24 **Cr** 1,6 52	25 **Mn** 1,5 55	26 **Fe** 1,8 56	27 **Co** 1,8 59	28 **Ni** 1,8 59	29 **Cu** 1,9 63,5	30 **Zn** 1,6 65	31 **Ga** 1,6 70	32 **Ge** 1,8 73	33 **As** 2,0 75	34 **Se** 2,4 79	35 **Br** 2,8 80	36 **Kr** 84
37 **Rb** 0,8 86	38 **Sr** 1,0 88	39 **Y** 1,2 89	40 **Zr** 1,4 91	41 **Nb** 92	42 **Mo** 1,8 96	43 **Tc** 1,9 101	44 **Ru** 2,2 101	45 **Rh** 2,2 103	46 **Pd** 2,2 106	47 **Ag** 1,9 108	48 **Cd** 1,7 112	49 **In** 1,7 115	50 **Sn** 1,8 119	51 **Sb** 1,9 122	52 **Te** 2,1 128	53 **I** 2,5 127	54 **Xe** 131
55 **Cs** 0,7 133	56 **Ba** 0,9 137	57 **La** 139	72 **Hf** 1,6 179	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 **Tℓ** 1,8 204	82 **Pb** 1,8 207	83 **Bi** 1,9 209	84 **Po** 2,0	85 **At** 2,5	86 **Rn**
87 **Fr** 0,7	88 **Ra** 0,9 226	89 **Ac**															

KEY/*SLEUTEL*

Atomic number / *Atoomgetal* → 29
Electronegativity / *Elektronegatiwiteit* → 1,9
Symbol / *Simbool* → **Cu**
Approximate relative atomic mass / *Benaderde relatiewe atoommassa* → 63,5

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

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

Increasing oxidising ability/*Toenemende oksiderende vermoë*

Increasing reducing ability/*Toenemende reduserende vermoë*

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

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

Increasing oxidising ability/*Toenemende oksiderende vermoë*

Increasing reducing ability/*Toenemende reduserende vermoë*