**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

FEBRUARY/MARCH 2018

MARKS: 150

TIME: 3 hours

This question paper consists of 16 pages, 4 data sheets and 1 graph sheet.

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 QUESTION 5.3 on the attached GRAPH PAPER. 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   Which ONE of the following is the general formula of alkynes?

     A C_nH_{2n}

     B $C_{2n}H_{2n}$

     C C_nH_{2n-2}

     D C_nH_{2n+2} (2)

1.2   The type of reaction that takes place when a carboxylic acid and an alcohol react in the presence of an acid:

     A   Addition

     B   Hydrolysis

     C   Substitution

     D   Esterification   (2)

1.3   Which ONE of the following isomers has the LOWEST boiling point?

     A $CH_3CH_2CH_2CH_2CH_2CH_3$

     B $CH_3CH_2C(CH_3)_2CH_3$

     C $CH_3CH(CH_3)CH_2CH_2CH_3$

     D $CH_3CH_2CH(CH_3)CH_2CH_3$ (2)

1.4   Which ONE of the reaction rate versus time graphs below best represents the reaction between magnesium and EXCESS dilute hydrochloric acid?
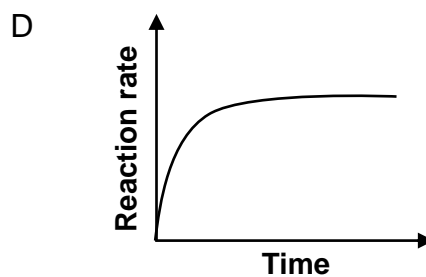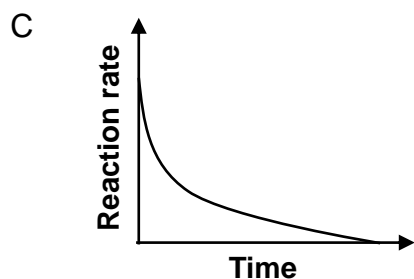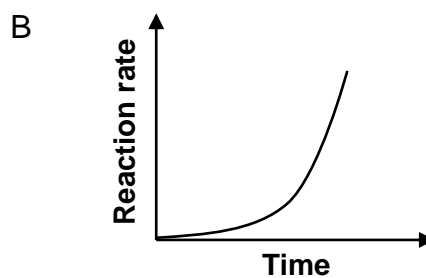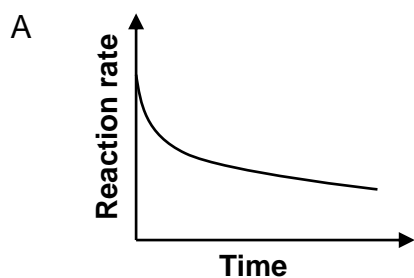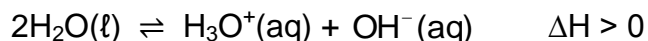

(2)

1.5   Which ONE of the following will NOT affect the equilibrium position of reversible chemical reactions?

   A   Temperature

   B   Catalyst

   C   Pressure

   D   Concentration   (2)

1.6   The following equilibrium exists in pure water at 25 °C.

$$2H_2O(\ell) \rightleftharpoons H_3O^+(aq) + OH^-(aq) \qquad \Delta H > 0$$
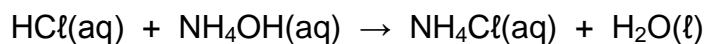
At this temperature, the pH = 7 and $K_w = 1 \times 10^{-14}$.

The temperature of the water is now increased to 90 °C.

Which ONE of the following is TRUE at the new temperature?

A   pH = 7

B $[H_3O^+] = [OH^-]$

C $[H_3O^+][OH^-] = 10^{-14}$

D $[H_3O^+] = 10^{-7}$ mol·dm^{-3} (2)

1.7   A hydrochloric acid solution is titrated against an ammonia solution.
        The balanced equation for the reaction is:

$$HC\ell(aq) + NH_4OH(aq) \rightarrow NH_4C\ell(aq) + H_2O(\ell)$$

Which ONE of the following gives the pH of the solution at the end point and
the reason for this pH?

	pH	REASON
A	3	$H_3O^+(aq)$ is formed during the ionisation of $HC\ell(aq)$.
B	5	$H_3O^+(aq)$ is formed during hydrolysis of $NH_4^+(aq)$.
C	7	Neutralisation takes place at the end point.
D	9	$OH^-(aq)$ is formed during hydrolysis of $NH_4^+(aq)$.

(2)

1.8   A decrease in the oxidation number of an atom during a chemical reaction is
        known as …

A   redox.

B   oxidation.

C   reduction.

D   electrolysis.   (2)

1.9   The two half-reactions below are used to construct a galvanic cell.

$$X^+(aq) + e^- \rightleftharpoons X(s) \qquad E^\theta_{reduction} = +0,15 \text{ V}$$

$$Y^{2+}(aq) + 2e^- \rightleftharpoons Y(s) \qquad E^\theta_{reduction} = -0,15 \text{ V}$$
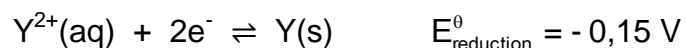
Which ONE of the statements below is CORRECT when the cell is in operation?

A $X^+(aq)$ is reduced.

B $Y(s)$ is reduced.

C $X(s) \mid X^+(aq)$ is the negative electrode.

D   Electrons flow from $X(s)$ to $Y(s)$ in the external circuit.   (2)

1.10   Which ONE of the following is CORRECT for the industrial preparation of sulphuric acid?

	PROCESS	CATALYST
A	Ostwald	Platinum
B	Haber	Iron
C	Contact	Iron
D	Contact	Vanadium pentoxide

(2)
[20]

QUESTION 2   (Start on a new page.)

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

A	(structural formula of compound A)	**B**	(structural formula of compound B)
C	Butan-1-ol	**D**	Butan-2-one
E	(structural formula of compound E)		

2.1   Write down the LETTER that represents EACH of the following:

   2.1.1   A tertiary alcohol   (1)

   2.1.2   An aldehyde   (1)

   2.1.3   A ketone   (1)

   2.1.4   A functional isomer of compound **B**   (1)

2.2   Write down the IUPAC name of:

   2.2.1   Compound **B**   (1)

   2.2.2   Compound **E**   (4)

2.3   Define *positional isomers*.   (2)

2.4   Write down the STRUCTURAL FORMULA of:

   2.4.1   A positional isomer of compound **C**   (2)

   2.4.2   Compound **D**   (2)

   2.4.3   The organic acid that will react with compound **C** to form
             butyl propanoate   (2)
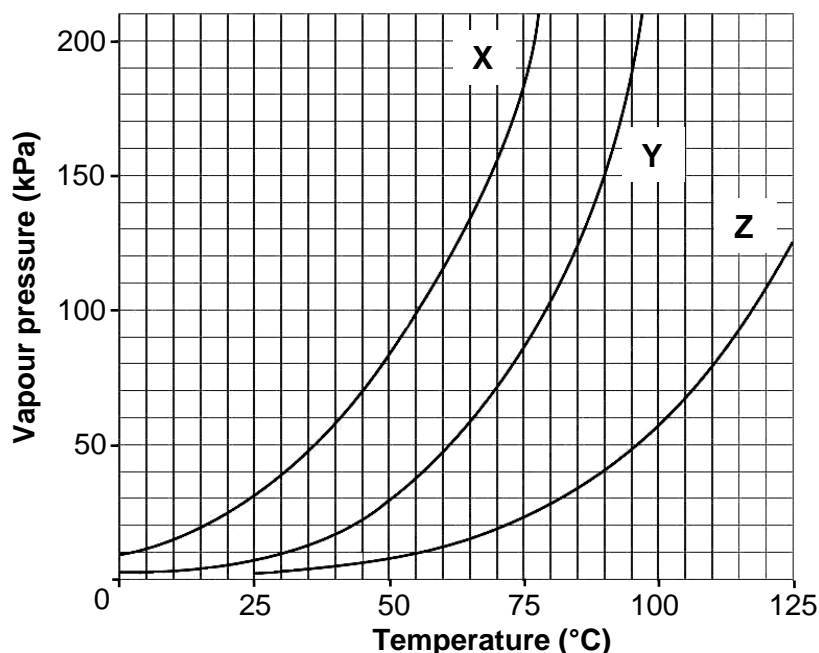
                                                                                                                [17]

QUESTION 3   (Start on a new page.)

Study the vapour pressure versus temperature graphs for three organic compounds, **X**, **Y** and **Z**, below which belong to different homologous series.

Atmospheric pressure is 100 kPa.

Graphs of vapour pressure versus temperature

3.1   Write down the vapour pressure of compound **Y** at 90 °C.   (1)

3.2   The graphs can be used to determine the boiling points of the three compounds.

   3.2.1   Define *boiling point.*   (2)

   3.2.2   Determine the boiling point of compound **X**.   (1)

3.3   The homologous series to which the three compounds of similar molecular masses belong, were identified in random order as:

   alcohol; carboxylic acid; ketone

   3.3.1   Which compound (**X**, **Y** or **Z**) is the carboxylic acid?   (1)

   3.3.2   Explain the answer to QUESTION 3.3.1 by referring to the type of intermolecular forces in compounds of each of the homologous series above.   (4)

   3.3.3   Compound **X** has three carbon atoms per molecule. Write down the IUPAC name of compound **X**.   (1)

   [10]

QUESTION 4   (Start on a new page.)

Consider the incomplete equations for reactions **I** to **IV** below. **P**, **Q**, **R** and **S** are organic compounds.

|	
I	**Q** + Br_2 ⟶ 2-bromobutane + HBr
II	n**P** ⟶ $-\left[-CH_2-CH_2-\right]_n-$
III	**R** $\xrightarrow{\text{heat}}$ 2**P** + **Q**
IV	2-bromobutane + KOH (in ethanol) $\xrightarrow{\text{heat}}$ **S** + **T** + H_2O

4.1   Define a *cracking reaction*.   (2)

4.2   Write down the reaction number (**I**, **II**, **III** or **IV**) that represents EACH of the following:

    4.2.1   A cracking reaction   (1)

    4.2.2   An addition reaction   (1)

    4.2.3   A substitution reaction   (1)

4.3   Write down:

    4.3.1   ONE reaction condition for reaction **I**   (1)

    4.3.2   The compound (**P**, **Q**, **R** or **S**) that represents an unsaturated hydrocarbon   (1)

    4.3.3   The IUPAC name of compound **P**   (1)

    4.3.4   The molecular formula of compound **R**   (2)

    4.3.5   The structural formula of compound **Q**   (2)

    4.3.6   The structural formula of compound **S**   (2)

[14]

QUESTION 5 (Start on a new page.)

ANSWER QUESTION 5.3 ON THE ATTACHED GRAPH PAPER.

Learners use the reaction between sodium thiosulphate and hydrochloric acid to investigate one of the factors that affects reaction rate. The balanced equation for the reaction is:

$$Na_2S_2O_3(aq) + 2HC\ell(aq) \rightarrow 2NaC\ell(aq) + H_2O(\ell) + SO_2(g) + S(s)$$

The diagram below shows the experimental setup.
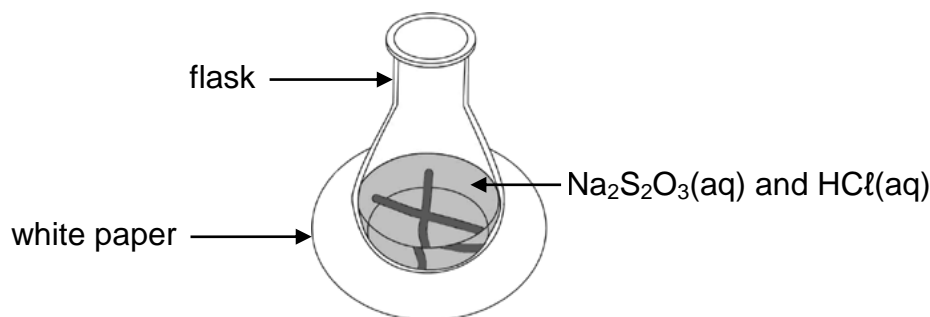
In the first experiment, 50 cm^3 of the sodium thiosulphate solution is added to 100 cm^3 of a 2 mol·dm^{-3} dilute hydrochloric acid solution in a flask that is placed over a cross drawn on a sheet of white paper. The hydrochloric acid is in EXCESS.

The time taken for the cross to become invisible, when viewed from the top, is recorded.

The experiment is then repeated four times with different volumes of the sodium thiosulphate solution. The results obtained are shown in the table below.

EXPERIMENT	VOLUME OF $Na_2S_2O_3$ (cm^3)	VOLUME OF H_2O (cm^3)	TIME (s)	AVERAGE RATE ($\frac{1}{time}$) (x 10^{-2} s^{-1})
1	50	0	22,7	4,4
2	40	10	28,6	3,5
3	30	20	38,5	2,6
4	20	30	58,8	1,7
5	10	40	111,1	0,9

5.1 Define *reaction rate*. (2)

5.2 How does the concentration of the sodium thiosulphate solution used in experiment **2** compare to that used in experiment **5**? Choose from MORE THAN, LESS THAN or EQUAL TO. (1)

5.3 Draw a graph of average reaction rate versus volume of sodium thiosulphate used on the attached GRAPH SHEET.
(ATTACH THIS GRAPH SHEET TO YOUR ANSWER BOOK.) (3)

5.4 Use the information in the graph to answer the following questions.

5.4.1 Determine the volume of dilute sodium thiosulphate solution that needs to react in order for the cross to become invisible in 40 seconds.

USE DOTTED LINES ON THE GRAPH TO SHOW HOW YOU ARRIVED AT THE ANSWER. (3)

5.4.2 Write down a conclusion for this investigation. (2)

5.5 Use the collision theory to explain the effect of an increase in concentration on reaction rate. (3)

5.6 The mass of sulphur produced in experiment **1** is 1,62 g. Calculate the mass of the sodium thiosulphate used in experiment **1**. (4)

[18]

QUESTION 6   (Start on a new page.)

6.1 A reversible gaseous reaction is allowed to reach equilibrium in a closed container at different temperatures and pressures.

The graph below shows the percentage yield for this reaction at 30 kPa as the temperature is increased.
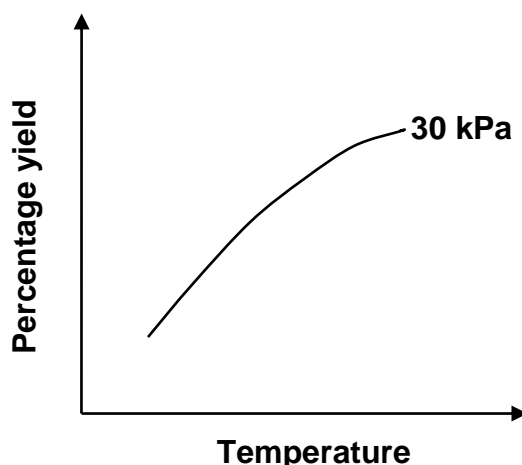
Use the information in the graph above to answer the following questions.

6.1.1 State Le Chatelier's principle. (2)

6.1.2 The heat of reaction (ΔH) for the forward reaction is POSITIVE. Use Le Chatelier's principle to explain this statement. (3)

The graph below show the percentage yield for this reaction as pressure changes at constant temperature.
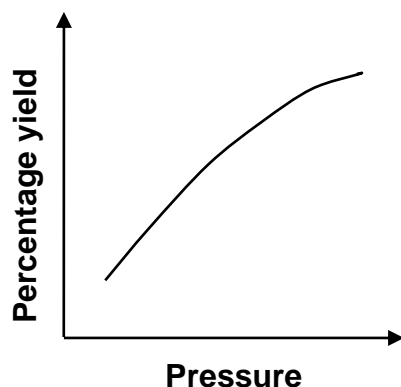
6.1.3   Explain the effect of an increase in pressure on the equilibrium position of a reaction.   (2)

6.1.4   Which ONE of the following equations (**I**, **II** or **III**) represents the equilibrium above?

I: $2A(g) + 3B(g) \rightleftharpoons 3C(g)$

II: $A(g) + B(g) \rightleftharpoons 3C(g)$

III: $A(g) + B(g) \rightleftharpoons 2C(g)$ (2)
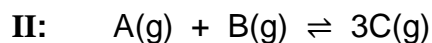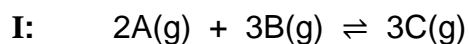
6.2   A mixture of 0,2 moles of hydrogen chloride (HCℓ) and 0,11 moles of oxygen gas (O_2) is sealed in a 200 cm^3 flask at a certain temperature. The reaction reaches equilibrium according to the balanced equation below:

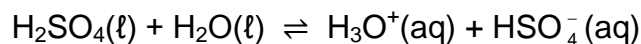$$4HCℓ(g) + O_2(g) \rightleftharpoons 2Cℓ_2(g) + 2H_2O(g)$$
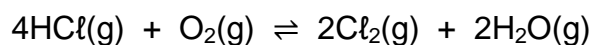
It is found that 1,825 g of hydrogen chloride is present at equilibrium.

Calculate the equilibrium constant, K_c, for this reaction at this temperature.   (9)

[18]

QUESTION 7   (Start on a new page.)

7.1   The balanced equation below represents the first step in the ionisation of sulphuric acid (H_2SO_4) in water:

$$H_2SO_4(\ell) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + HSO_4^-(aq)$$

      7.1.1   Write down the FORMULAE of the TWO bases in the equation above.   (2)

      7.1.2   Is sulphuric acid a STRONG or a WEAK acid? Give a reason for the answer.   (2)

7.2   Learners use the reaction of a 0,15 $mol \cdot dm^{-3}$ sulphuric acid solution with a sodium hydroxide solution in two different experiments. The balanced equation for the reaction is:

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + H_2O(\ell)$$
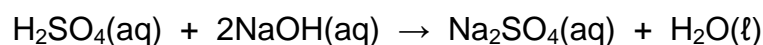
      7.2.1   They use 24 cm^3 of $H_2SO_4(aq)$ in a titration to neutralise 26 cm^3 of NaOH(aq).

                   Calculate the concentration of the NaOH(aq).   (5)

      7.2.2   In another experiment, 30 cm^3 of the $H_2SO_4(aq)$ is added to 20 cm^3 of a 0,28 $mol \cdot dm^{-3}$ NaOH solution in a beaker.

                   Calculate the pH of the final solution.   (8)

                                                                            [17]

QUESTION 8   (Start on a new page.)

8.1   A group of learners use the redox reaction below to construct an electrochemical cell.

$$Sn^{2+}(aq) \ + \ 2Ag^+(aq) \ \rightarrow \ 2Ag(s) \ + \ Sn^{4+}(aq)$$
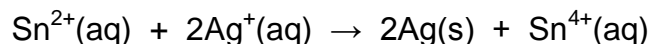
8.1.1   Define a *reducing agent* in terms of *electron transfer*.   (2)

8.1.2   Name a substance that should be used as electrode in the anode half-cell.   (1)

8.1.3   Write down the NAME or FORMULA of the reducing agent.   (1)

8.1.4   Write down the cell notation of the cell.   (3)

8.1.5   Calculate the initial emf of this cell under standard conditions.   (4)

8.2   In a separate experiment, the learners place magnesium ribbon in a beaker containing a blue solution of copper(II) sulphate. After a while the solution becomes colourless.

Copper(II) sulphate solution ⟶   ⟵ Magnesium ribbon
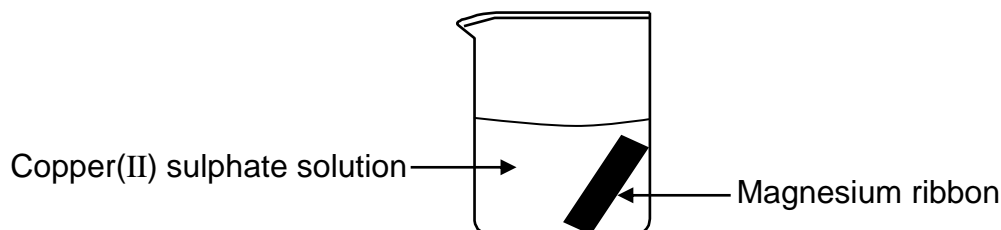
8.2.1   State ONE observable change in the beaker, besides a colour change of the solution, that the learners can make.   (1)

8.2.2   Refer to the relative strengths of oxidising agents or reducing agents to explain why the solution becomes colourless.   (3)

[15]

QUESTION 9 (Start on a new page.)

The graph below represents the changes in mass that occur at electrode **A** and electrode **B** in an electrolytic cell during the purification of copper.
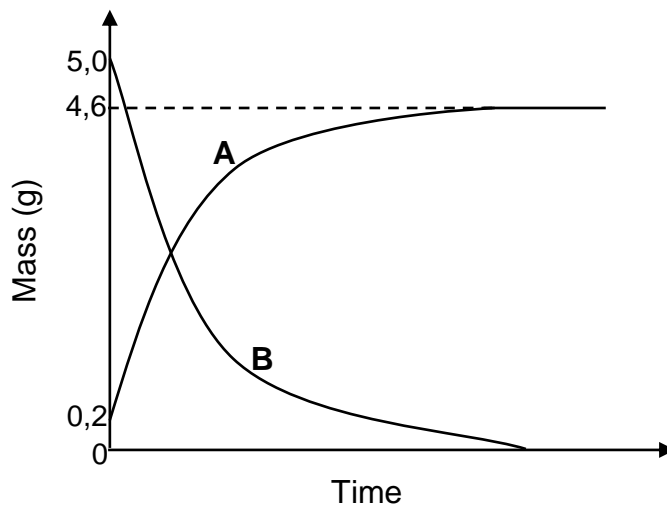
9.1   Define *electrolysis*.   (2)

9.2   Which graph, **A** or **B**, represents the change in mass of the anode during
        electrolysis?   (1)

9.3   Write down the equation of the half-reaction which takes place at the cathode
        of this cell.   (2)

9.4   Use the information in the graph and calculate the percentage purity of the
        impure copper.   (4)

                                                                                                [9]

QUESTION 10 (Start on a new page.)

10.1   The diagram below shows processes involved in the production of fertiliser **X** and fertiliser **Z**.

```
                        ┌──────────────────┐
                        │  Haber process   │
                        └──────────────────┘
                                 │
                                 ▼
  ┌───┐   H₂SO₄   ┌──────────────┐  Process A   ┌──────┐  Product Q   ┌───┐
  │ X │ ◄───────  │  Product Q   │ ──────────►  │ HNO₃ │ ──────────►  │ Z │
  └───┘           └──────────────┘              └──────┘              └───┘
```
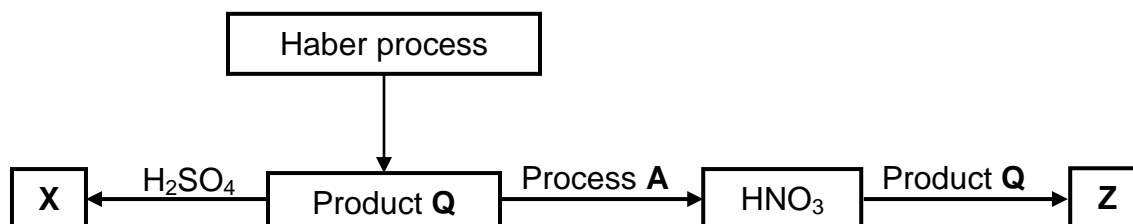
Write down the:

10.1.1   Balanced equation for the formation of product **Q**   (3)

10.1.2   FORMULA of fertiliser **X**   (1)

10.1.3   NAME of process **A**   (1)

10.1.4   NAME of fertiliser **Z**   (1)

10.2   A 10 kg bag of NPK fertiliser is labelled 6 **:** 1 **:** 5 (22).

10.2.1   What is the meaning of NPK?   (1)

10.2.2   What is the meaning of (22) on the label?   (1)

10.2.3   Calculate the mass of potassium in the bag.   (4)
                                                                            [12]

                                                            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^+]

$$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14} \text{ at/} by \text{ 298 K}$$

$$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode} \,/\, E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$$

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

KEY/*SLEUTEL*

Atomic number
Atoomgetal

Electronegativity
Elektronegatiwiteit →

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

← Symbol
Simbool

Approximate relative atomic mass
Benaderde relatiewe atoommassa

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** 101	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

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
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-$	+ 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
$Br_2(\ell) + 2e^- \rightleftharpoons 2Br^-$	+ 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
$Al^{3+} + 3e^- \rightleftharpoons Al$	− 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*

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

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

Increasing oxidising ability/*Toenemende oksiderende vermoë*

Increasing reducing ability/*Toenemende reduserende vermoë*

CENTRE NUMBER:													
EXAMINATION NUMBER:													

QUESTION 5.3

Hand in this GRAPH SHEET with your ANSWER BOOK.

Graph of reaction rate versus volume

Average reaction rate $(\times 10^{-2}\ s^{-1})$ versus Volume of $Na_2S_2O_3(aq)$ (cm^3)