higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

PHYSICAL SCIENCE
(Second paper)
NQF LEVEL 4

(10021004)

4 December 2020 (X-paper)
09:00–12:00

A non-programmable calculator may be used.

This question paper consists of 16 pages, 1 table of standard reduction potentials and 1 periodic table.

313Q2N2004

TIME: 3 HOURS
MARKS: 150

INSTRUCTIONS AND INFORMATION

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Start each question on a new page.
5. Appropriate mathematical instruments should be used.
6. Show all formulae and substitutions in all calculations.
7. Round off all final numerical answers to a minimum of TWO decimal places.
8. Write your EXAMINATION NUMBER and CENTRE NUMBER in the appropriate spaces on the ANSWER BOOK
9. Give brief motivations, discussions, etc. where required.
10. Write neatly and legibly.

SECTION A

QUESTION 1

Give a term for each of the following descriptions. Write only the answer next to the question number (1.1–1.5) in the ANSWER BOOK.

1.1 Radiation that can be stopped by a piece of cardboard.

1.2 The element in fertiliser that promotes the flowering of plants.

1.3 Weak intermolecular forces present in all organic molecules.

1.4 Process in which large organic molecules are broken down into smaller units.

1.5 High-speed electrons ejected from the nucleus during radioactivity.

(5 × 1) **[5]**

QUESTION 2

Choose an item from COLUMN B that matches a description in COLUMN A. Write only the letter (A–L) next to the question number (2.1–2.5) in the ANSWER BOOK.

	COLUMN A		COLUMN B
2.1	SI unit second for nuclear transformations per second	A	end point
2.2	Responsible for the low vapour pressure of carboxylic acids	B	concentration
2.3	Stage in a titration when an indicator changes colour	C	mol·dm^{-3}
2.4	Solution with equal concentrations of hydroxide and hydronium ions	D	becquerel
2.5	Indicates the acidity or alkalinity of a solution	E	melting point
		F	covalent bonding
		G	neutral
		H	hydrogen bonding
		I	standard solution
		J	sodium hydroxide
		K	pH
		L	curie

(5 × 1) **[5]**

QUESTION 3

Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (3.1–3.5) in the ANSWER BOOK.

3.1 The burning of coal increases the carbon dioxide content of the atmosphere.

3.2 The shelf life of fresh fruit is increased by exposure to radiation.

3.3 Moderators slow down fast-moving protons in a nuclear reactor.

3.4 The polymerisation of ethene produces polyvinyl chloride.

3.5 Protons are transferred in a redox reaction.

(5 × 2) **[10]**

QUESTION 4

Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (4.1–4.5) in the ANSWER BOOK.

4.1 The table shows the count rate of a radioactive source taken at regular time intervals. The count rate has been corrected for background radiation.

Time (minutes)	10	20	30	40	50
Count rate (counts per minute)	800	630	500	400	315

What is the half-life of an isotope, in minutes?

A 40
B 30
C 20
D 10

4.2 A mixture of carbon monoxide and hydrogen can be converted into water and a mixture of hydrocarbons.

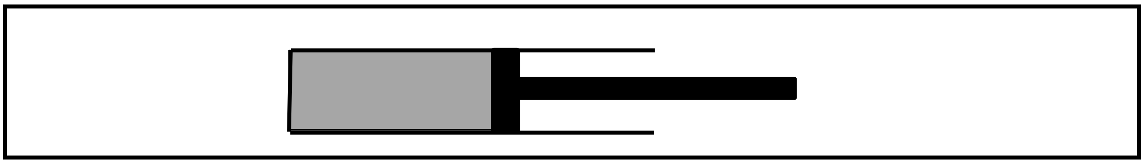
$$\mathbf{n}\,CO + (2\mathbf{n}+1)\,H_2 \rightarrow \mathbf{n}\,H_2O + \text{hydrocarbons}$$

What is the general formula for the hydrocarbons produced?

A C_nH_{2n}
B C_nH_{2n-2}
C C_nH_{2n+1}
D C_nH_{2n+2}

4.3 A pale brown mixture of N_2O_4 and NO_2 is allowed to reach chemical equilibrium in a sealed gas syringe according to the following equation.

$$2NO_2 \rightleftarrows N_2O_4$$



When the plunger is pushed further into the syringe, the pressure increases, and the mixture becomes paler in colour.

When the syringe is placed in hot water, the mixture becomes darker in colour.

Which ONE of the following statements is correct?

A NO_2 is brown and the forward reaction is exothermic.
B NO_2 is brown and the forward reaction is endothermic.
C NO_2 is colourless and the forward reaction is exothermic.
D NO_2 is colourless and the forward reaction is endothermic.

4.4 The reactions below take place in two different electrochemical cells, **P** and **Q.**

Cell **P**: $CuC\ell_2(aq) \rightarrow Cu(s) + C\ell_2(g)$

Cell **Q**: $Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$

Which ONE of the following correctly represents the product that is formed at the CATHODE of each cell?

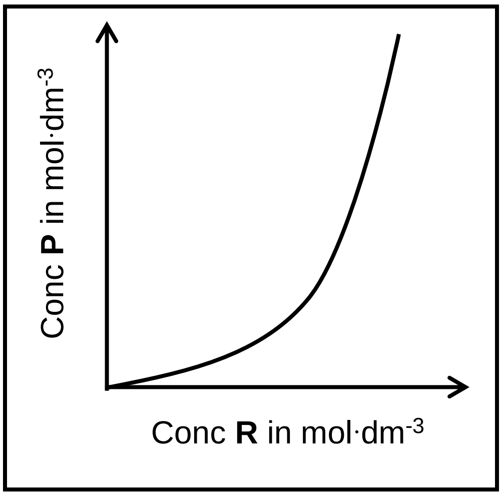
	Cell P	**Cell Q**
A	$C\ell_2(g)$	$ZnSO_4(aq)$
B	$C\ell_2(g)$	$Cu(s)$
C	$Cu(s)$	$Cu(s)$
D	$Cu(s)$	$ZnSO_4(aq)$

4.5 The chemical equation below represents a closed system in equilibrium at 25 ^{0}C.

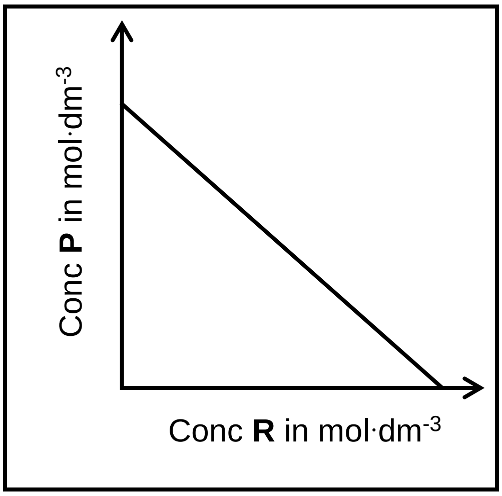
$$2\mathbf{R} \leftrightarrows \mathbf{P}$$

Which ONE of the graphs CORRECTLY represents the relationship between the concentrations of **P** and **R** at 25 ^{0}C

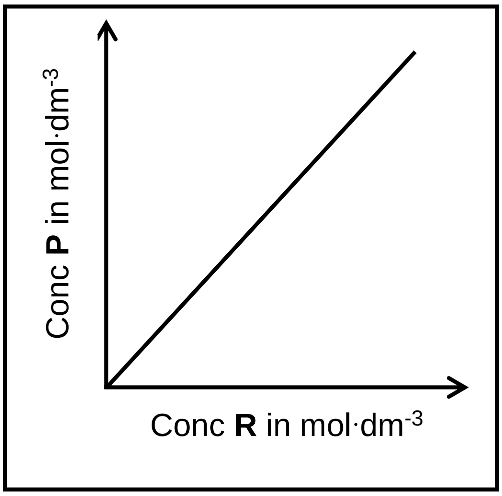
A



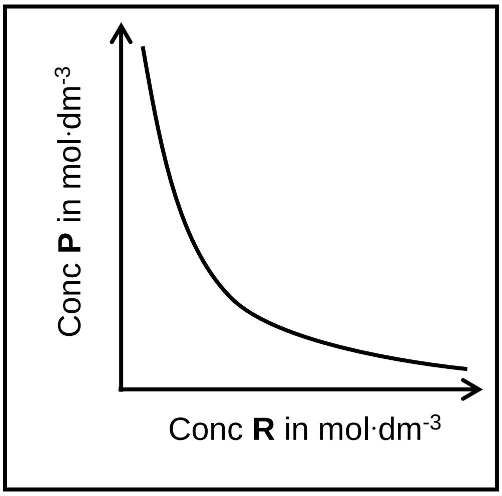
B



C



D



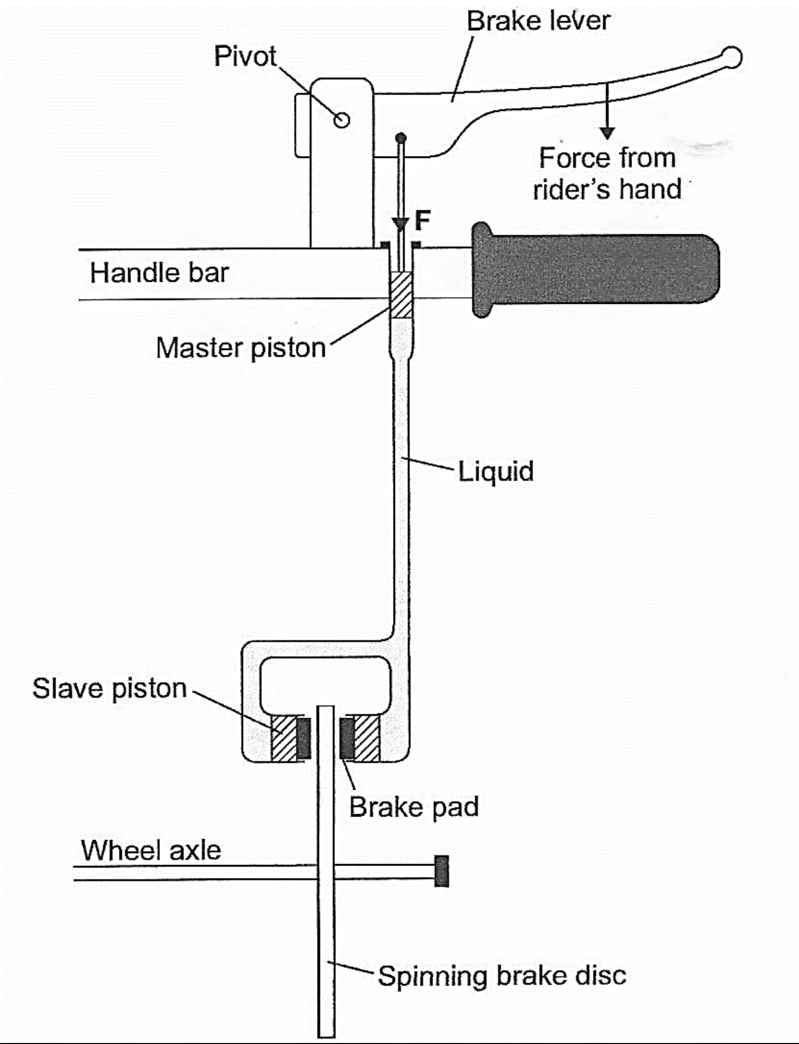
(5 × 3) **[15]**

TOTAL SECTION A: 35

SECTION B

QUESTION 5

5.1 Some mountain bikes use liquid-filled pipes to transmit the force from the rider's hand on the brake lever to the brake pads. These brakes are illustrated below.



5.1.1 Name the principle on which this braking system operates. (1)

5.1.2 Complete the following sentences by writing only the correct option of those given in brackets next to the question number ((a)–(b)) in the ANSWER BOOK.

(a) Liquids can be used to transmit the forces in a brake system because liquids (are incompressible; can flow; take the shape of the container).

(b) The pressure in the liquid is transmitted (sideways; downwards; in all directions).

(2 × 1) (2)

5.1.3 When the rider's hand pulls the brake lever, the force F applied to the liquid by the master piston is 80 N. The cross-sectional area of this piston is 50 mm^2.

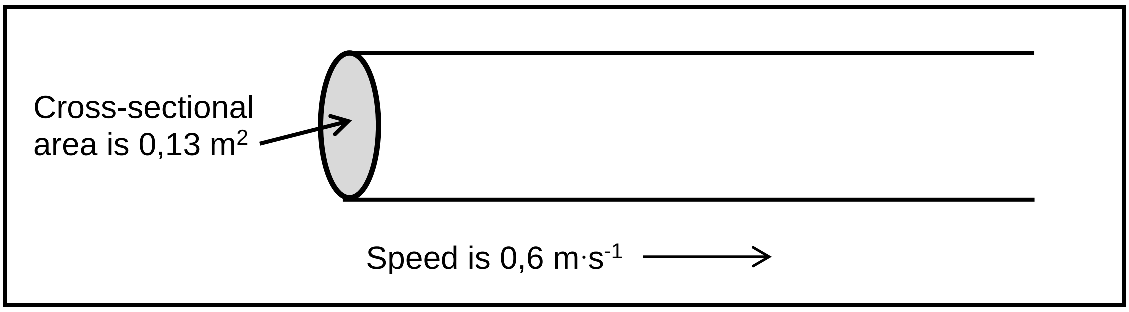
Calculate the following:

(a) The pressure exerted on the liquid by the master piston

(b) The force exerted by the liquid on the slave piston which has an area of 2×10^{-4} m^2

(2 × 3) (6)

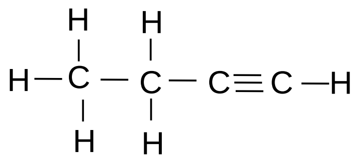
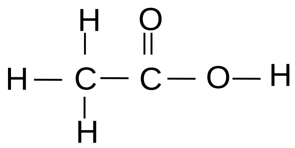
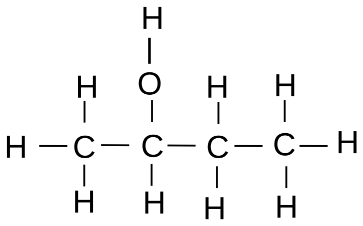
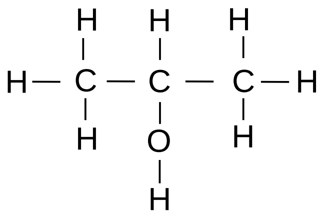
5.2 Water flows at a speed of 0,6 $m \cdot s^{-1}$ in a horizontal pipe which has a cross-sectional area of 0,13 m^2.



What is the flow rate of the liquid in the pipe? (1)
[10]

QUESTION 6

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

A.		**D.**	
B.	Ethene	**E.**	Propane
C.		**F.**	

6.1 Natural gases and petroleum are sources of hydrocarbons.

6.1.1 What are *hydrocarbons?* (2)

6.1.2 Write a balanced equation for the combustion of compound E in excess oxygen. (3)

6.2 Isomers are compounds with the same molecular formula but different structures.

6.2.1 Draw the structural formula for a tertiary alcohol of compound C**.**

6.2.2 What is the IUPAC name for the answer to QUESTION 6.2.1?

(2 × 2) (4)

6.3 A homologous series is defined by a general formula and a functional group.

6.3.1 Write the general formula for the homologous series to which compound B belongs. (2)

6.3.2 Name the functional group of compound F. (2)

6.3.3 What is the IUPAC name for:

(a) Compound A

(b) Compound D

(2 × 2) (4)

6.4 Compound B (ethene) reacts with hydrogen gas under certain reaction conditions.

$$\text{Ethene} + H_2 \rightleftharpoons \textbf{P}$$

6.4.1 Is the organic reactant SATURATED or UNSATURATED? (1)

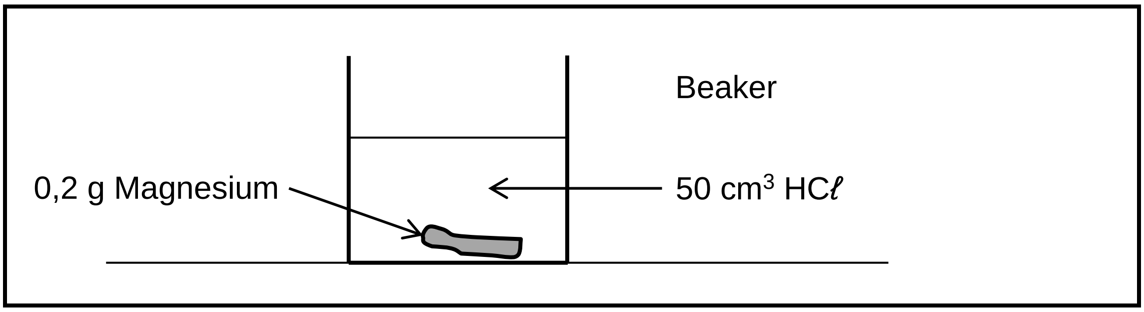
6.4.2 Give ONE reason for the answer to QUESTION 6.4.1 (2)

6.4.3 State TWO conditions required for this reaction. (2)

6.4.4 Name the product P. (2)
[24]

QUESTION 7

7.1 A student investigated the rate of the reaction between magnesium and excess hydrochloric acid using the apparatus illustrated below.



She followed the following procedure:

- Poured 50 cm^3 of HCℓ into a clean, dry beaker.
- Added 0,2 g Mg into the beaker and simultaneously started a stopwatch.
- Stopped the watch when no more gas bubbles were produced.
- Recorded the reaction time.
- Repeated the experiment using different reaction conditions.

The reaction that occurred is: $Mg + 2\,HC\ell \rightarrow MgC\ell_2 + H_2$

The following results were tabulated:

EXPERIMENT	TEMPERATURE OF ACID (°C)	CONCENTRATION OF ACID	MAGNESIUM	REACTION TIME (s)
A	25	diluted	ribbon	240
B	25	concentrated	ribbon	120
C	30	diluted	ribbon	100
D	25	diluted	powder	50

7.1.1 State TWO conditions necessary for an effective collision according to the kinetic collision theory. (2)

7.1.2 Calculate the average reaction rate for experiment A in $mol \cdot s^{-1}$. (4)

7.1.3 What is the independent variable in:

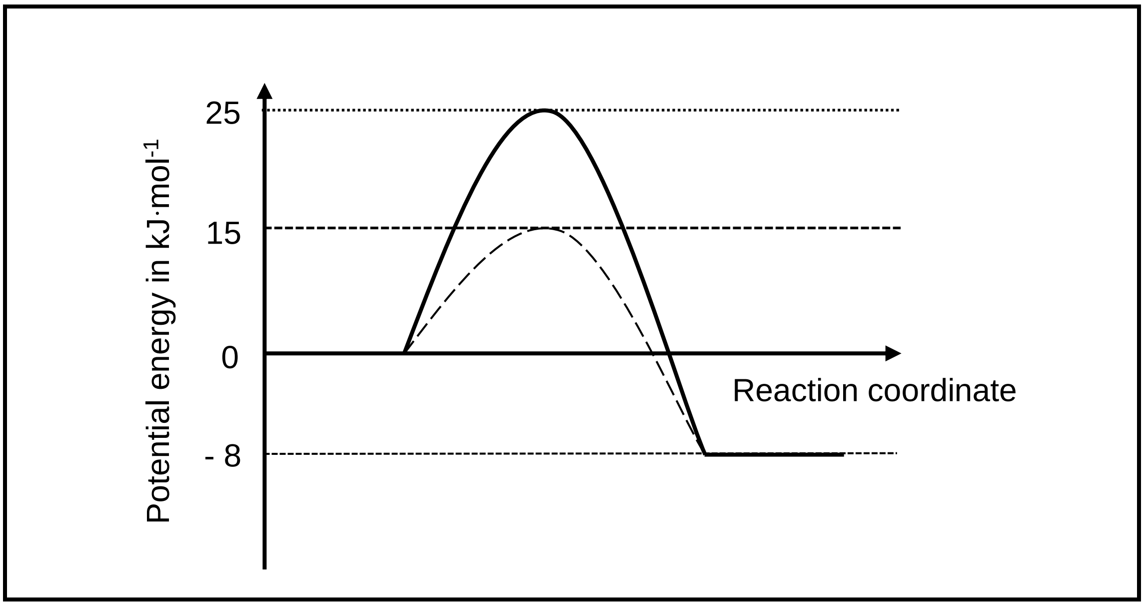
(a) Experiments A and B

(b) Experiments A and D

(2 × 1) (2)

7.1.4 Write a suitable conclusion for experiments A and C. (2)

7.2 The following graph illustrates the potential energy changes during a catalysed (--------) and an uncatalysed (————) reaction.



7.2.1 Is this reaction EXOTHERMIC or ENDOTHERMIC? (1)

7.2.2 Give ONE reason for the answer to QUESTION 7.2.1. (1)

7.2.3 From the graph, calculate the following:

(a) The change in the potential energy of the activated complex by the addition of a catalyst

(b) The activation energy for the reverse catalysed reaction

(2 × 1) (2)

[14]

QUESTION 8

At high temperatures and in the presence of a catalyst, sulphur trioxide decomposes according to the following equation:

$$2SO_3(g) \leftrightarrows 2SO_2(g) + O_2(g) \qquad \Delta H > 0$$

In an experiment, 0,8 moles of sulphur trioxide were placed in a container with a volume of 2 dm^3 and allowed to reach chemical equilibrium at temperature T_1.

At temperature T_1 the equilibrium concentration of oxygen was 0,07 $mol{\cdot}dm^{-3}$

8.1 What is the initial concentration of sulphur trioxide? (3)

8.2 Determine the equilibrium concentration of the following:

8.2.1 $SO_2(g)$

8.2.2 $SO_3(g)$

(2 × 1) (2)

8.3 Calculate the equilibrium constant (K_c) for this equilibrium at temperature T_1. (3)

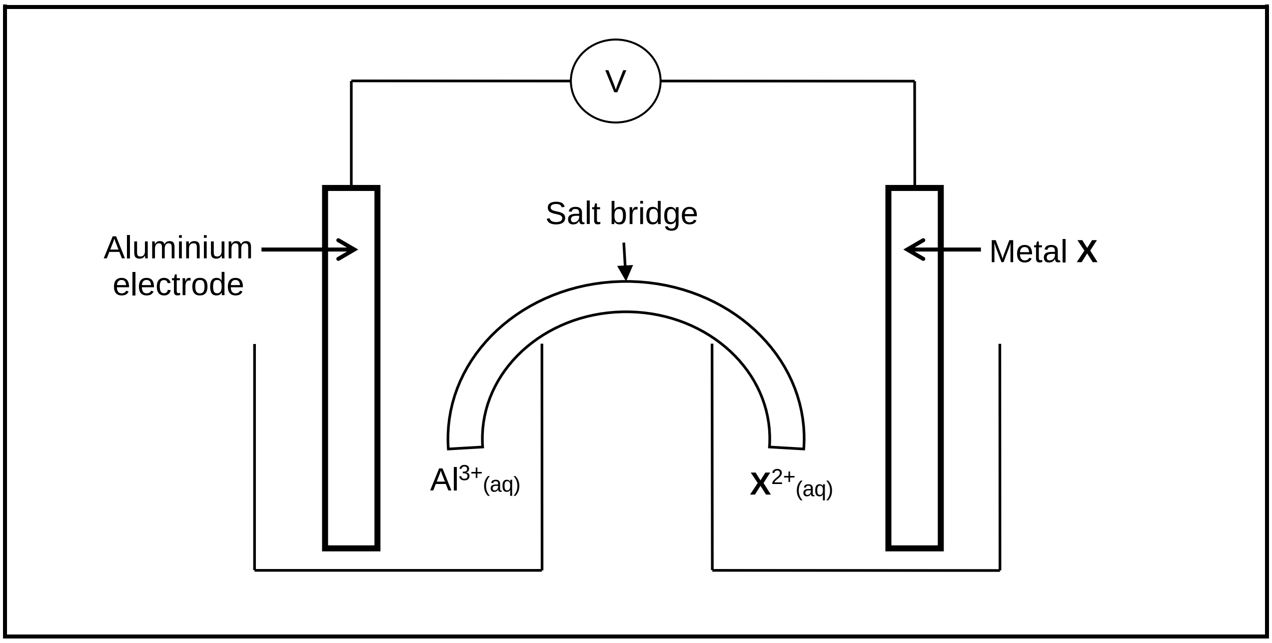
8.4 If the temperature of this equilibrium system is increased, will the value of K_c INCREASE, DECREASE or REMAIN CONSTANT? (1)

8.5 Explain the answer to QUESTION 8.4. (3)

[12]

QUESTION 9

A voltaic cell is constructed by connecting an aluminium half-cell to another half-cell constructed from metal X as shown in the sketch below.



In the external circuit, electrons flow from the aluminium electrode to metal X. Under standard conditions, the initial voltmeter reading is 1,52 V.

9.1 Represent this cell in standard notation. (3)

9.2 If potassium nitrate was used to make the salt bridge, write down the formula of the ion that migrates into the aluminium half-cell when the cell is in operation. (2)

9.3 Which metal forms the anode, ALUMINIUM or METAL X? (1)

9.4 State TWO standard conditions under which the maximum voltmeter reading is 1,52 V. (2)

9.5 Identify metal X by using a suitable calculation. Show all workings clearly. (4)

9.6 Will the initial cell potential INCREASE, DECREASE or REMAIN THE SAME if each of the following changes are made to this cell?

9.6.1 The concentration of $Al^{3+}_{(aq)}$ is increased.

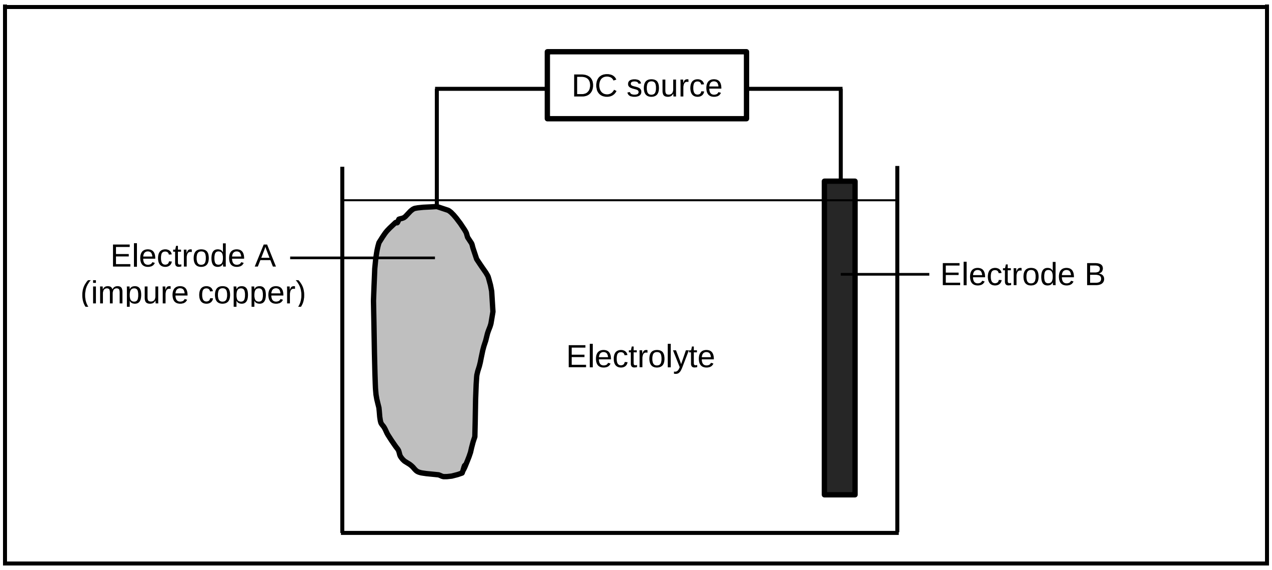
9.6.2 The size of the Metal X electrode is increased.

(2 × 1) (2)

[14]

QUESTION 10

The diagram below represents an electrochemical cell used for the purification of copper.



10.1 What energy conversion occurs in this cell? (2)

10.2 Which electrode, A or B, forms the anode? (1)

10.3 Write down the half-reaction that takes place at electrode B. (2)

10.4 Due to small amounts of nickel impurities in the impure copper, the electrolyte becomes contaminated with Ni^{2+} ions.

Refer to the attached Table of Standard Reduction Potentials to explain why the Ni^{2+} ions will not influence the purity of the copper obtained during this process. (4)

[9]

QUESTION 11

11.1 Oxalic acid is a weak, diprotic acid. It ionises in two steps as follows:

Step 1: $C_2O_4H_2(aq) + H_2O(l) \leftrightarrows H_3O^+(aq) + C_2O_4H^-(aq)$

Step 2: $C_2O_4H^-(aq) + H_2O(l) \leftrightarrows H_3O^+(aq) + C_2O_4^{2-}(aq)$

11.1.1 Write down the Arrhenius definition of a base. (2)

11.1.2 Write down the *formula* of the conjugate base of $H_3O^+(aq)$. (1)

11.1.3 Write down the *formula* of the substance that acts as an ampholyte in the ionisation of oxalic acid. (2)

11.2 A 500 cm^3 solution was prepared by mixing 7,84 g of a sodium carbonate hydrate with formula $Na_2CO_3 \cdot nH_2O$ in sufficient water.

In a titration,10 cm^3 of the sodium carbonate solution was used to exactly neutralise 16 cm^3 of a 0,1 $mol \cdot dm^3$ HCl solution.

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

11.2.1 Calculate the concentration of the sodium carbonate solution used in the titration. (4)

11.2.2 Determine the mass of water in 7,84 g of the sodium carbonate hydrate. (5)

11.2.3 Calculate the value of 'n'. (4)

[18]

QUESTION 12

12.1 There are many isotopes of the element molybdenum (Mo).

What do the nuclei of the different isotopes of molybdenum have in common? (2)

12.2 The isotope molybdenum-99 is produced inside a nuclear power stations from the nuclear fission of uranium-235.

12.2.1 What is *nuclear fission*? (2)

12.2.2 Inside which part of a nuclear power station would molybdenum-99 be produced? (1)

12.3 When the nucleus of a molybdenum-99 atom decays, it emits radiation and changes into a nucleus of technetium-99.

$$^{99}_{42}\text{Mo} \rightarrow \, ^{99}_{43}\text{Tc} + \text{Radiation}$$

12.3.1 What type of radiation is emitted by molybdenum-99? (1)

12.3.2 Give a reason for the answer to QUESTION 12.3.1. (2)

12.4 Technetium-99 has a half-life of 6 hours and emits gamma radiation.

In spite of some risk to the patient's health, doctors inject it into a patient's body and use it as a medical tracer for diagnostic purposes.

12.4.1 What is meant by *half-life*?

12.4.2 If a patient is injected with 4 g of technetium-99, calculate the quantity that will remain in the body at the end of 24 hours?

12.4.3 Explain how the risk to the patient is reduced when injected with radioactive substances used as tracers.

(3 × 2) (6)

[14]

TOTAL SECTION B: 115

GRAND TOTAL: 150

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

Increasing oxidising ability/*Toenemende oksiderende vermoë* (↑)

Increasing reducing ability/*Toenemende reduserende vermoë* (↓)

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

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

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↓

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

Increasing reducing ability/*Toenemende reduserende vermoë* ↑

PERIODIC TABLE

Key

Atomic number (Z)	Electro-negativity	Symbol	Atomic radius (pm)	1st ionisation energy (kJ.mol^{-1})	Relative atomic mass
1	2,1	H	37	1310	1

	I	II											III	IV	V	VI	VII	0
1	1 2,1 **H** 37 1310 1																	2 **He** 93 2360 4
2	3 1,0 **Li** 152 520 7	4 1,5 **Be** 111 900 9											5 2,0 **B** 79 790 10,8	6 2,5 **C** 77 1090 12	7 3,0 **N** 74 1400 14	8 3,5 **O** 74 1310 16	9 4,0 **F** 71 1680 19	10 **Ne** 112 2080 20
3	11 0,9 **Na** 186 490 23	12 1,2 **Mg** 160 730 24,3											13 1,5 **Al** 143 580 27	14 1,8 **Si** 118 780 28	15 2,1 **P** 110 105 31	16 2,5 **S** 102 1000 32	17 3,0 **Cl** 100 1250 35,5	18 **Ar** 154 1520 40
4	19 0,8 **K** 227 415 39	20 1,0 **Ca** 197 590 40	21 1,3 **Sc** 161 635 45	22 1,5 **Ti** 145 655 48	23 1,6 **V** 131 645 51	24 1,6 **Cr** 125 655 52	25 1,5 **Mn** 137 710 55	26 1,8 **Fe** 124 760 56	27 1,8 **Co** 125 760 59	28 1,8 **Ni** 125 730 59	29 1,9 **Cu** 128 740 63,5	30 1,6 **Zn** 133 910 65,4	31 1,6 **Ga** 122 580 70	32 1,8 **Ge** 123 780 72,6	33 2,0 **As** 124 965 75	34 2,4 **Se** 116 945 79	35 2,8 **Br** 114 1140 80	36 **Kr** 169 1350 84
5	37 0,8 **Rb** 248 410 85,5	38 1,0 **Sr** 215 550 88	39 1,2 **Y** 178 635 69	40 1,4 **Zr** 159 675 91	41 1,6 **Nb** 143 655 93	42 1,8 **Mo** 136 960 96	43 1,9 **Tc** 133 99	44 2,2 **Ru** 133 720 101	45 2,2 **Rh** 135 740 103	46 2,2 **Pd** 138 800 106	47 1,9 **Ag** 144 730 108	48 1,7 **Cd** 149 865 112	49 1,7 **In** 163 560 115	50 1,8 **Sn** 141 705 119	51 1,9 **Sb** 145 830 112	52 2,1 **Te** 143 865 128	53 2,5 **I** 133 1000 127	54 **Xe** 190 1160 131
6	55 0,7 **Cs** 265 375 133	56 **Ba** 137,4		72 **Hf**	73 **Ta**	74 **W**	75 **Re**	76 **Os**	77 **Ir**	78 **Pt**	79 **Au**	80 **Hg**	81 **Tl**	82 **Pb** 207	83 **Bi**	84 **Po**	85 **At**	86 **Rn**
	87 **Fr**	88 **Ra**																

57 **La**	58 **Ce**	59 **Pr**	60 **Nd**	61 **Pm**	62 **Sm**	63 **Eu**	64 **Gd**	65 **Tb**	66 **Dy**	67 **Ho**	68 **Ei**	69 **Tm**	70 **Yb**	71 **Lu**
89 **Ac**	90 **Th**	91 **Pa**	92 **U**	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**	103 **Lw**