basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

PHYSICAL SCIENCES: CHEMISTRY (P2)

2023

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 NINE 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, e.g. between QUESTION 2.1 and QUESTION 2.2.

6. You may use a non-programmable calculator.

7. You may use appropriate mathematical instruments.

8. Show ALL formulae and substitutions in ALL calculations.

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

10. Give brief motivations, discussions, etc. where required.

11. You are advised to use the attached DATA SHEETS.

12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 E.

1.1 For which ONE of the following molecular formulae are CHAIN isomers possible?

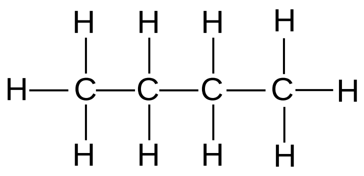
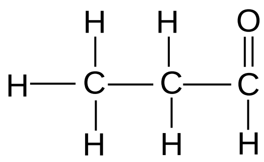
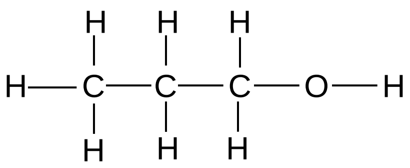
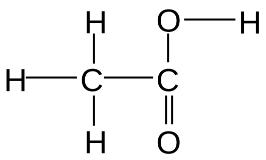
A C_4H_{10}

B C_3H_8

C C_2H_6O

D C_3H_8O (2)

1.2 Which ONE of the following compounds has the LOWEST vapour pressure under the same conditions?

A		B	
C		D	

(2)

1.3 The type of organic compound formed when a haloalkane is heated in the presence of a concentrated strong base is an …

A alkane.

B alkene.

C alkyne.

D alcohol. (2)

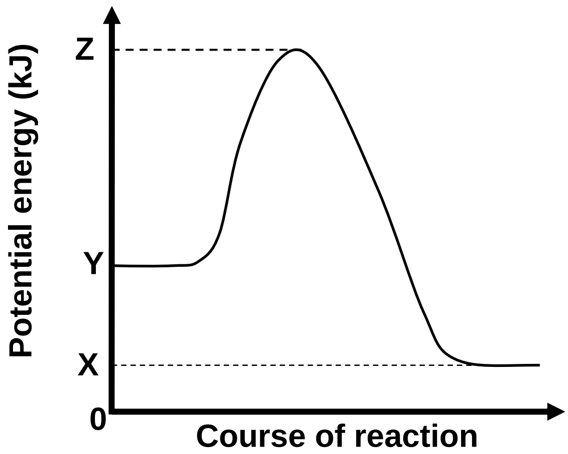
1.4 EXCESS HCℓ(aq) of concentration 0,1 mol·dm^{-3} reacts with 2 g of Mg under different conditions.

Which ONE of the following combinations of conditions will produce the largest volume of H_2(g) in the FIRST MINUTE of the reaction?

	STATE OF DIVISION OF Mg	**TEMPERATURE OF HCℓ(aq) (°C)**
A	Powder	20
B	Granules	20
C	Powder	50
D	Granules	50

(2)

1.5 The potential energy diagram for a chemical reaction is shown below.



Which ONE of the following combinations is CORRECT for the FORWARD reaction?

	ΔH	**ACTIVATION ENERGY**	**POTENTIAL ENERGY OF THE ACTIVATED COMPLEX**
A	**Y–X**	**Z+Y**	**Z**
B	**Y–X**	**Z–Y**	**Z+Y**
C	**X–Y**	**Z–Y**	**Z**
D	**X–Y**	**Z**	**Z–Y**

(2)

1.6 Consider the following reaction that reaches equilibrium in a beaker:

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(\ell)$$

A few drops of concentrated NaOH(aq) are now added to the beaker.

Which ONE of the following combinations correctly identifies the DISTURBANCE ON THE SYSTEM and the SYSTEM'S RESPONSE to the disturbance?

	DISTURBANCE ON THE SYSTEM	**SYSTEM'S RESPONSE**
A	$[H^+]$ decreases	Forward reaction favoured
B	$[H^+]$ decreases	Reverse reaction favoured
C	$[CrO_4^{2-}]$ decreases	Reverse reaction favoured
D	$[CrO_4^{2-}]$ increases	Forward reaction favoured

(2)

1.7 According to the Lowry-Brønsted theory, a conjugate base is formed when a/an …

A proton is added to the acid.

B electron is added to the acid.

C proton is removed from the acid.

D electron is removed from the acid. (2)

1.8 Consider the statements below regarding an alkaline substance.

An alkaline substance:

(i) Reacts with an acid to form a neutral solution

(ii) Turns red litmus blue

(iii) Forms a salt when it reacts with an acid

Which of the statements above are ALWAYS TRUE?

A (i), (ii) and (iii)

B (i) and (ii) only

C (i) and (iii) only

D (ii) and (iii) only (2)

1.9 Consider the cell notation for a galvanic cell.

$$Pt \mid H_2(g) \mid OH^-(aq) \mid H_2O(\ell) \parallel Ag^+(aq) \mid Ag(s)$$

Which ONE of the following equations represents the half-reaction taking place at the positive electrode?

A $Ag^+(aq) + e^- \rightarrow Ag(s)$

B $Ag(s) \rightarrow Ag^+(aq) + e^-$

C $2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

D $H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(\ell) + 2e^-$ (2)

1.10 A concentrated solution of sodium chloride, $NaC\ell(aq)$, undergoes electrolysis.

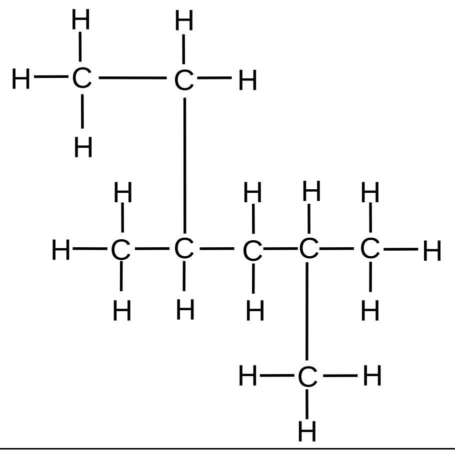
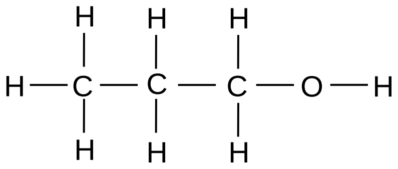
Which ONE of the combinations correctly shows the products formed at each electrode?

	CATHODE	**ANODE**
A	Na	$C\ell_2$
B	H_2	OH^-
C	$C\ell_2$	H_2 and OH^-
D	H_2 and OH^-	$C\ell_2$

(2)
[20]

QUESTION 2 (Start on a new page.)

Study the table below and answer the questions that follow.

A		**B**	
C	C_4H_8O	**D**	$CH_3(CH_2)_4CHCH_2$
E	$C_XH_YO_Z$		

2.1 Define the term *unsaturated* hydrocarbon. (2)

2.2 Write down the:

2.2.1 Letter that represents an UNSATURATED hydrocarbon (1)

2.2.2 IUPAC name of compound **A** (3)

2.2.3 IUPAC name of the POSITIONAL isomer of compound **B** (2)

2.2.4 IUPAC name of compound **D** (2)

2.2.5 Balanced equation, using MOLECULAR FORMULAE, for the complete combustion of compound **A** (3)

2.3 The formula C_4H_8O represents two compounds that are functional isomers of each other.

2.3.1 Define the term *functional isomer*. (2)

2.3.2 Write down the STRUCTURAL FORMULAE of each of these two FUNCTIONAL isomers. (4)

2.4 A 2 g sample of compound **E** contains 1,09 g carbon and 0,18 g hydrogen. The molecular mass of compound **E** is 88 g·mol^{-1}.

Determine the molecular formula of compound **E** by means of a calculation. (6)

[25]

QUESTION 3 (Start on a new page.)

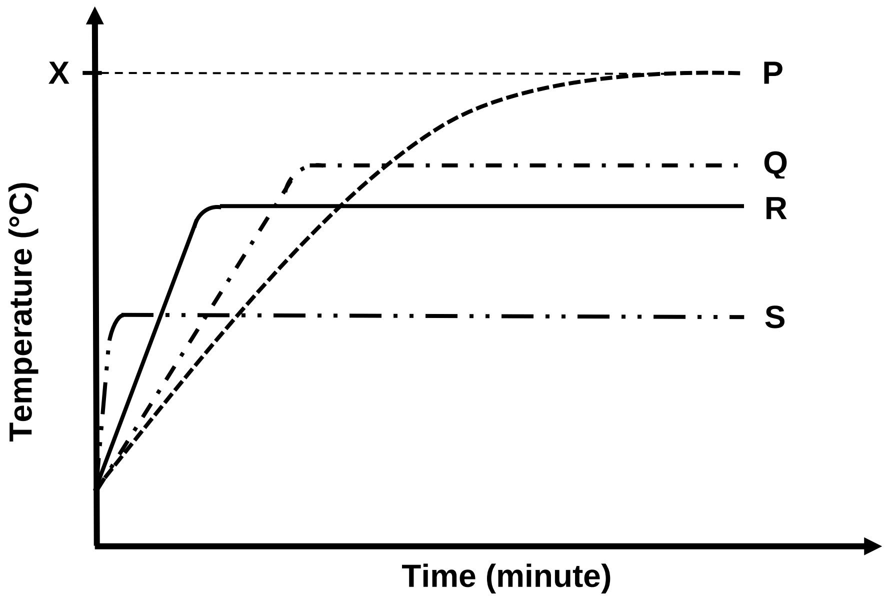
Learners investigate the boiling points of the four organic compounds given below.

ORGANIC COMPOUND	MOLECULAR MASS ($g \cdot mol^{-1}$)
Butanone	72
Butan-1-ol	74
Propanoic acid	74
2-methylpropan-1-ol	74

3.1 Define the term *boiling point.* (2)

3.2 Which compound, butan-1-ol or 2-methylpropan-1-ol, will have the higher boiling point? Fully explain the answer. (4)

The curves **P**, **Q**, **R** and **S** below were obtained from the results of the investigation. **X** represents a specific temperature.



3.3 Which physical property is represented by temperature **X**? (1)

3.4 Which curve (**P**, **Q**, **R** or **S**) represents:

3.4.1 Butanone (1)

3.4.2 Propanoic acid (1)

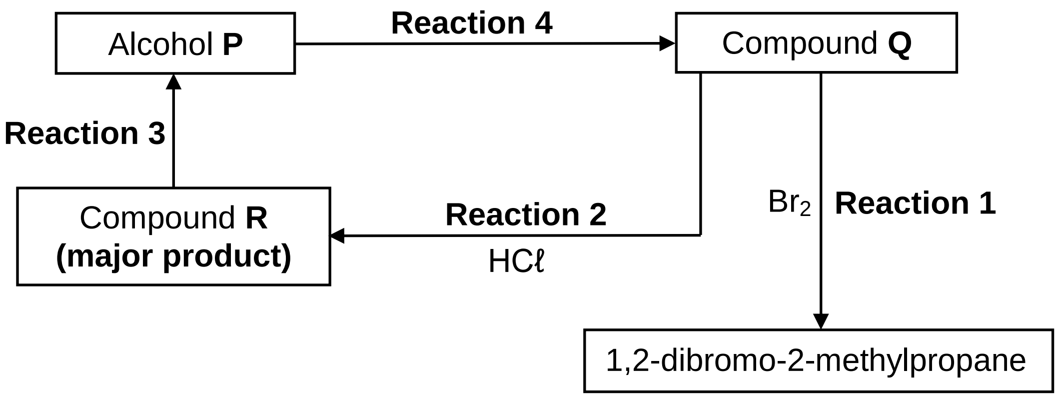
3.4.3 2-methylpropan-1-ol (1)

3.5 Give a reason for the answer to QUESTION 3.4.2. (1)

[11]

QUESTION 4 (Start on a new page.)

4.1 The flow diagram below shows different organic reactions.
P, **Q** and **R** are organic compounds.



Reaction 1 is an addition reaction.

Write down:

4.1.1 The TYPE of addition reaction (1)

4.1.2 ONE observable change which occurs in the container during the reaction (1)

4.1.3 The STRUCTURAL FORMULA of compound **Q** (2)

Consider **reaction 2**.

4.1.4 Write down the IUPAC name of compound **R**. (2)

For **reaction 3**, write down:

4.1.5 A balanced equation using STRUCTURAL FORMULAE for the organic compounds (6)

4.1.6 The IUPAC name of alcohol **P** (2)

Reaction 4 is an elimination reaction.

4.1.7 Write down the TYPE of elimination reaction. (1)

4.2 Butan-1-ol reacts with propanoic acid in the presence of a catalyst.

Write down the:

4.2.1 TYPE of reaction that takes place (1)

4.2.2 IUPAC name of the organic product formed (2)
[18]

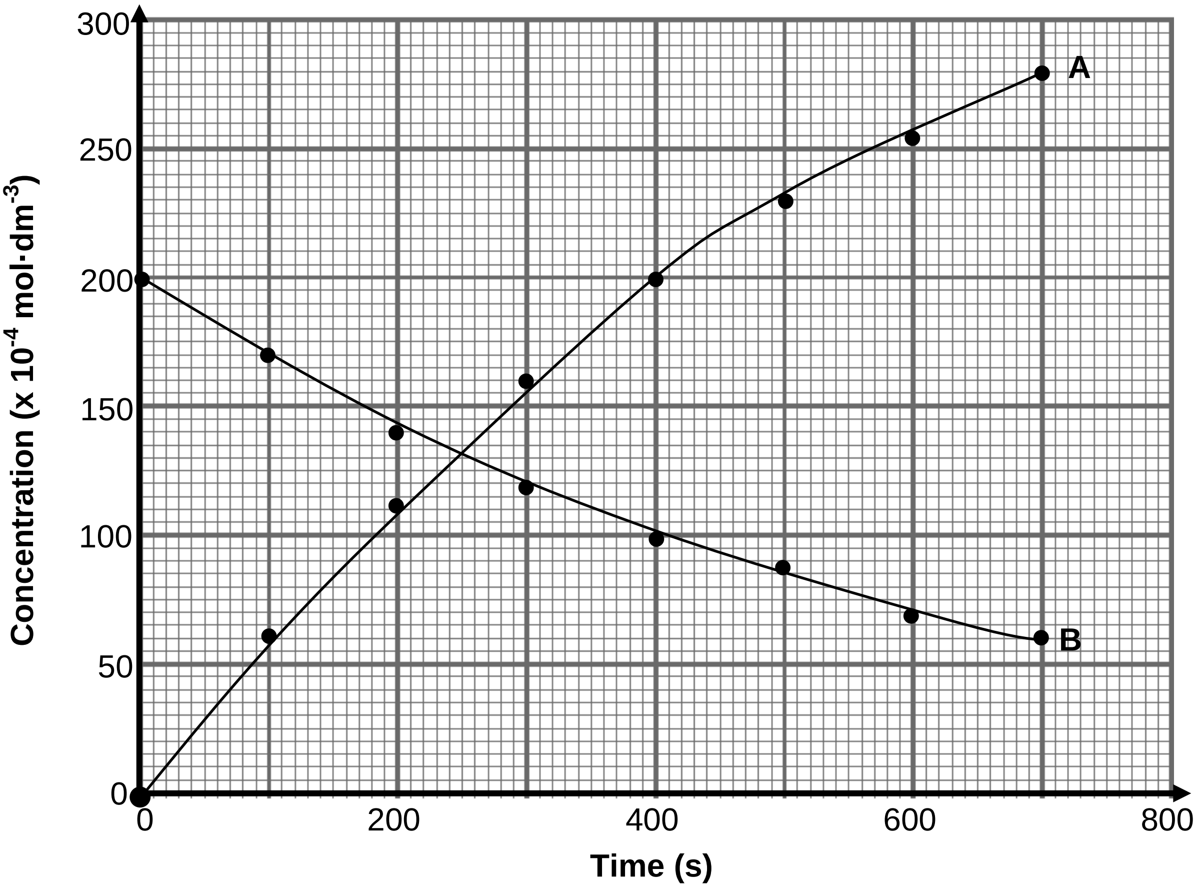
QUESTION 5 (Start on a new page.)

Consider the following decomposition reaction that takes place in a sealed 2 dm^3 container:

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

The graph below shows how the concentrations of $N_2O_5(g)$ and $NO_2(g)$ change with time.

Concentration-time graph



5.1 Refer to the graph above and give a reason why curve **A** represents the change in the concentration of $NO_2(g)$. (1)

5.2 Consider the statement below:

The rate of decomposition of $N_2O_5(g)$ is half the rate of formation of $NO_2(g)$.

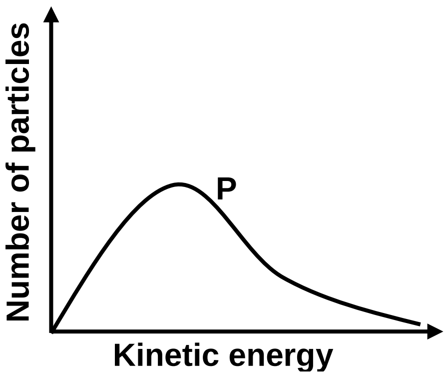
Is this statement TRUE or FALSE? Give a reason for the answer. (2)

5.3 Calculate the:

5.3.1 Mass of $NO_2(g)$ present in the container at 400 s (4)

5.3.2 Average rate of production of $O_2(g)$ in $mol{\cdot}dm^{-3}{\cdot}s^{-1}$ in 700 s (4)

5.4 The Maxwell-Boltzmann distribution curve for the $N_2O_5(g)$ initially present in the container is shown below.



The initial concentration of the $N_2O_5(g)$ is now INCREASED.

5.4.1 Redraw the distribution curve above in the ANSWER BOOK and label this curve as **P**.

On the same set of axes, sketch the curve that will be obtained for the higher concentration of $N_2O_5(g)$. Label this curve as **Q**. (2)

5.4.2 Will the rate of decomposition of $N_2O_5(g)$ at the higher concentration be HIGHER THAN, LOWER THAN or EQUAL TO the original rate of decomposition? Explain the answer using the collision theory. (3)

[16]

QUESTION 6 (Start on a new page.)

One mole of pure hydrogen iodide gas, HI(g), is sealed in a 1 dm^3 container at 721 K. Equilibrium is reached according to the following balanced equation:

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

It is found that 0,11 moles of I_2(g) are present at equilibrium.

6.1 State Le Chatelier's principle. (2)

6.2 Determine the number of moles of EACH of the following at equilibrium:

6.2.1 H_2(g) (1)

6.2.2 HI(g) (1)

6.3 The equilibrium constant, K_c, at 721 K is 0,02.

The temperature of the container is now increased to 850 K.
The equilibrium constant, K_c, at 850 K is 0,09.

6.3.1 Is the forward reaction EXOTHERMIC or ENDOTHERMIC? (1)

6.3.2 Fully explain the answer to QUESTION 6.3.1. (3)

6.3.3 Calculate the mass of HI(g) present at the new equilibrium at 850 K. (8)

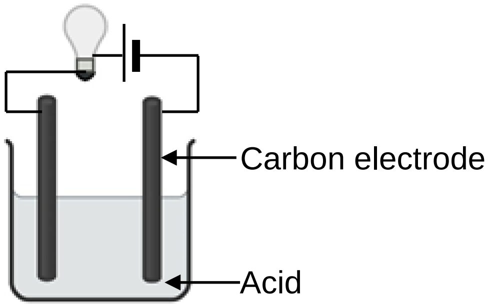
[16]

QUESTION 7 (Start on a new page.)

7.1 The conductivity of three acid solutions, **A**, **B** and **C**, as shown below is investigated at the same temperature.

A	0,1 mol·dm^{-3} $H_2SO_4(aq)$
B	0,1 mol·dm^{-3} $HNO_3(aq)$
C	0,1 mol·dm^{-3} $CH_3COOH(aq)$

The brightness of the bulb in the apparatus shown below is used as a measure of the conductivity of the solutions.



The acid solutions are electrolytes.

7.1.1 Define the term *electrolyte*. (2)

The brightness of the bulb for each of the solutions is compared.

7.1.2 In which solution, **A** or **B**, will the bulb be brighter? Give a reason for the answer by referring to the types of acids. (2)

7.1.3 In which solution, **B** or **C**, will the bulb be brighter? Give a reason for the answer by referring to the types of acids. (2)

7.2 A hydrochloric acid solution, HCℓ(aq), is standardised by titrating it against 25 cm^3 of a 0,04 $mol{\cdot}dm^{-3}$ sodium carbonate solution Na_2CO_3(aq). At the endpoint, it is found that 19,5 cm^3 of HCℓ(aq) has reacted.

The balanced equation for the reaction is:

$$Na_2CO_3(aq) + 2HC\ell(aq) \rightarrow 2NaC\ell(aq) + CO_2(g) + H_2O(\ell)$$

7.2.1 Calculate the concentration of the HCℓ(aq). (3)

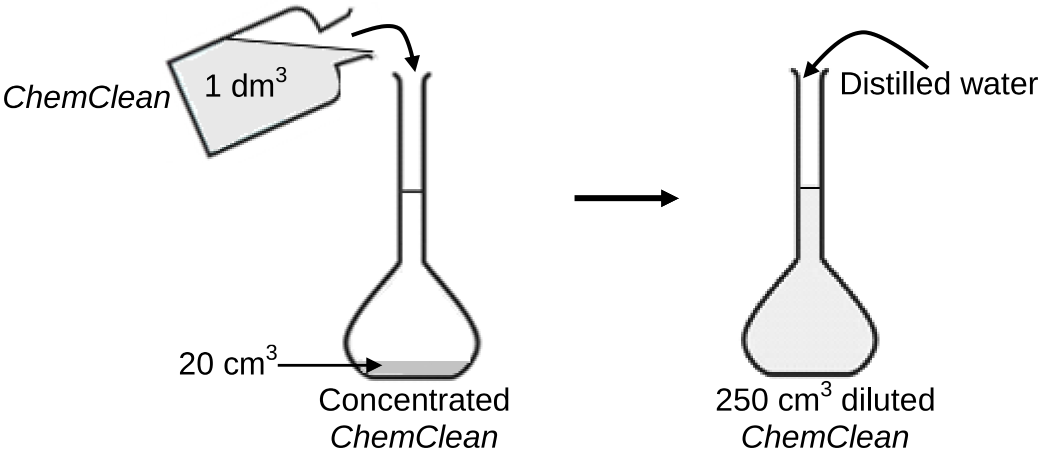
7.2.2 Suppose a few drops of water were present in the burette before it was filled with the hydrochloric acid solution.

How will the volume of the HCℓ solution needed to reach the endpoint be affected?

Choose from GREATER THAN, SMALLER THAN or REMAINS THE SAME. Give a reason for the answer. (2)

A concentrated household product, *ChemClean*, contains ammonia as the main cleaning agent. To determine the amount of ammonia present in 1 dm^3 of *ChemClean*, the following procedure is followed:

20 cm^3 of *ChemClean* is added to a 250 cm^3 flask. The flask is then filled to the 250 cm^3 mark with distilled water.



The diluted solution is titrated against the hydrochloric acid solution of the concentration as calculated in QUESTION 7.2.1.

During the titration, 22 cm^3 of the diluted *ChemClean* solution is neutralised by 18,7 cm^3 of the HCℓ solution. The balanced equation for the reaction is:

$$NH_3(aq) + HC\ell(aq) \rightarrow NH_4^+(aq) + C\ell^-(aq)$$

7.2.3 Calculate the mass of ammonia in 1 dm^3 of *ChemClean*. (7)

7.2.4 Will the pH of the solution at the end of the titration be GREATER THAN 7, EQUAL TO 7 or LESS THAN 7?

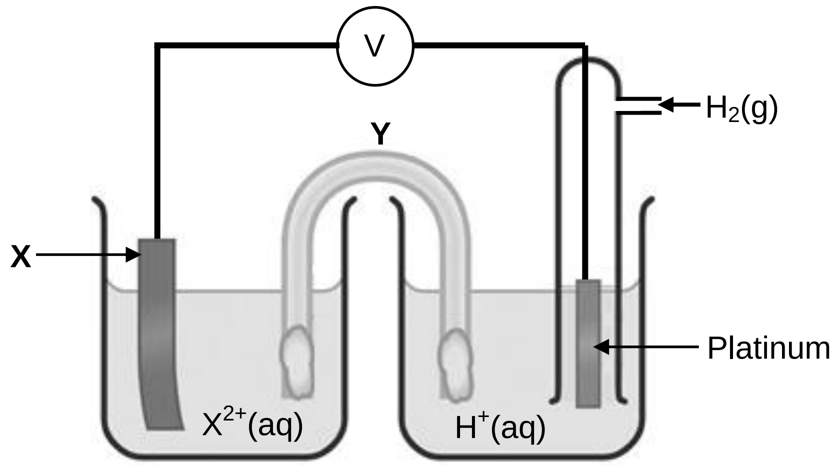
Write down the relevant equation as motivation for the answer. (3)

[21]

QUESTION 8 (Start on a new page.)

Learners want to identify an unknown metal **X** using a standard half-cell, $X|X^{2+}$.

They set up an electrochemical cell under standard conditions using two half-cells, as shown in the diagram below.



The initial emf of this cell is 1,20 V.

8.1 State the standard conditions under which this cell functions. (3)

8.2 State ONE function of component **Y**. (1)

After the cell has operated for some time, it is found that the mass of electrode **X** has increased.

8.3 Identify **X** by means of a suitable calculation. (5)

8.4 Write down the oxidation half-reaction that takes place in this cell. (2)

Half-cell $X|X^{2+}$ is now replaced by an $Au|Au^{3+}$ half-cell.

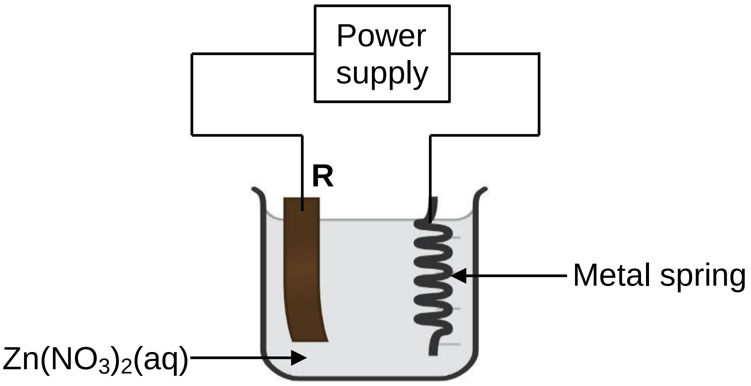
The initial emf of the cell is now 1,50 V. As the cell operates, the Au electrode increases in mass.

8.5 Arrange the oxidising agents, X^{2+}, Au^{3+} and H^+, in order of increasing strength.

Fully explain the answer. (3)
[14]

QUESTION 9 (Start on a new page.)

The simplified electrolytic cell below is used to electroplate a metal spring. Zinc nitrate, $Zn(NO_3)_2(aq)$, is used as an electrolyte and **R** is an electrode.



9.1 Define the term *electrolytic cell.* (2)

9.2 Which electrode (**R** or **METAL SPRING**) is the ANODE? Give a reason for the answer. (2)

9.3 Write down the:

9.3.1 Equation for the half-reaction occurring at the metal spring (2)

9.3.2 NAME or FORMULA of a suitable metal that can be used as electrode **R** (1)

9.4 Explain the answer to QUESTION 9.3.2. (2)
[9]

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*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ 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* $E^{\theta}_{cell} = E^{\theta}_{oxidising agent} - E^{\theta}_{reducing agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	
$I = \frac{Q}{\Delta t}$	$n = \frac{Q}{q_e}$ where n = number of electrons

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

KEY/*SLEUTEL*

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

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**	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)
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 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

Increasing strength of oxidising agents /*Toenemende sterkte van oksideermiddels* (↑)

Increasing strength of reducing agents /*Toenemende sterkte van reduseermiddels* (↓)

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

Increasing strength of oxidising agents /*Toenemende sterkte van oksideermiddels* (↓)

Increasing strength of reducing agents /*Toenemende sterkte van reduseermiddels* (↑)

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