basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

NOVEMBER 2015

MARKS: 150

TIME: 3 hours

This question paper consists of 15 pages and 4 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the appropriate spaces on the ANSWER BOOK.

2. 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

Four 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 number (1.1–1.10) in the ANSWER BOOK, for example 1.11 E.

1.1 Which ONE of the following pairs of reactants is used in a reaction during the contact process?

A $N_2(g)$ and $H_2(g)$

B $SO_2(g)$ and $O_2(g)$

C $NH_3(g)$ and $O_2(g)$

D $H_2SO_4(\ell)$ and $NH_3(g)$ (2)

1.2 The rate of a chemical reaction is most correctly defined as the ...

A time taken for a reaction to occur.

B speed at which a reaction takes place.

C change in the amount of reactants or products.

D change in the concentration of reactants or products per unit time. (2)

1.3 Consider the reaction represented by the balanced equation below.

$$H_3PO_4(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + H_2PO_4^-(aq)$$

Which ONE of the following is a conjugate acid-base pair?

A $H_3O^+(aq)$ and $H_2O(\ell)$

B $H_3PO_4(aq)$ and $H_2O(\ell)$

C $H_3PO_4(aq)$ and $H_3O^+(aq)$

D $H_3O^+(aq)$ and $H_2PO_4^-(aq)$ (2)

1.4 Which ONE of the following compounds has dipole-dipole forces between its molecules?

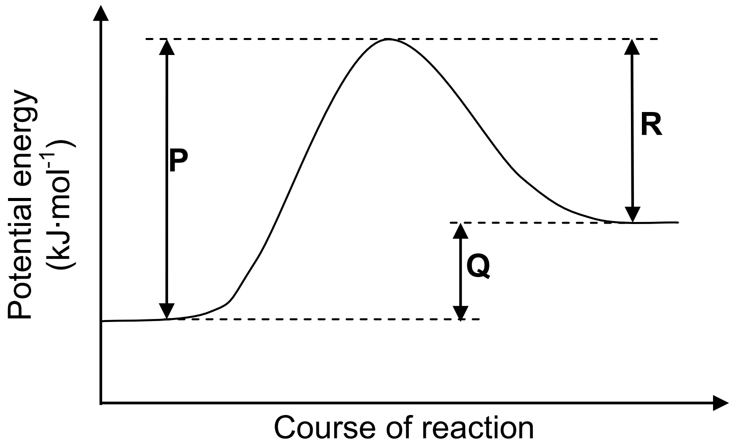
A Ethanal

B Ethane

C Ethene

D Ethyne (2)

1.5 The energy changes represented by **P**, **Q** and **R** on the potential energy graph below take place during a reversible chemical reaction.



Which ONE of the following changes will decrease both **P** and **R**, but leave **Q** unchanged?

A A decrease in volume

B The addition of a catalyst

C A decrease in temperature

D A decrease in concentration (2)

1.6 Which ONE of the following is a product formed during the hydrolysis of bromoethane?

A Water

B Ethene

C Ethanol

D Bromine (2)

1.7 Which ONE of the following is the EMPIRICAL FORMULA of 1,2-dichloroethane?

A $CHC\ell$

B $CH_2C\ell$

C $CHC\ell_2$

D $C_2H_4C\ell_2$ (2)

1.8 The reaction represented by the balanced equation below reaches equilibrium in a closed container.

$$C\ell_2(g) + H_2O(\ell) \rightleftharpoons C\ell^-(aq) + C\ell O^-(aq) + 2H^+(aq)$$

Which ONE of the following reagents will favour the forward reaction when added?

A Hydrogen

B Sodium chloride

C Hydrogen chloride

D Sodium hydroxide (2)

1.9 The following half-reactions take place in a galvanic cell:

$$Co^{3+} + e^- \rightleftharpoons Co^{2+}$$
$$A\ell^{3+} + 3e^- \rightleftharpoons A\ell$$

Which ONE of the following is the cell notation for this cell?

A $A\ell \mid A\ell^{3+} \parallel Co^{3+}, Co^{2+}$

B $A\ell \mid A\ell^{3+} \parallel Co^{3+}, Co^{2+} \mid Pt$

C $A\ell \mid A\ell^{3+} \parallel Co^{2+}, Co^{3+} \mid Pt$

D $Pt \mid Co^{2+}, Co^{3+} \parallel A\ell^{3+} \mid A\ell$ (2)

1.10 Chlorine gas ($C\ell_2$) is bubbled through a potassium iodide solution (KI). The reducing agent in this reaction is:

A Potassium ions

B Chlorine gas

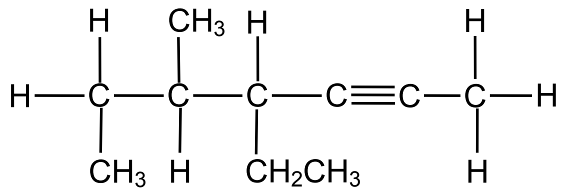
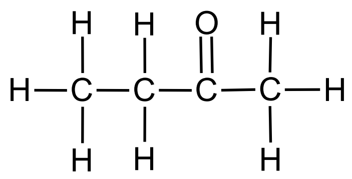
C Iodide ions

D Chloride ions (2)

[20]

QUESTION 2 (Start on a new page.)

The letters **A** to **D** in the table below represent four organic compounds.

A		**B**	
C	CH_3CH_2CHO	**D**	Butane

Use the information in the table to answer the questions that follow.

2.1 Write down the:

2.1.1 Letter that represents a ketone (1)

2.1.2 Structural formula of the functional group of compound **C** (1)

2.1.3 General formula of the homologous series to which compound **A** belongs (1)

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

2.1.5 IUPAC name of compound **B** (2)

2.2 Compound **D** is a gas used in cigarette lighters.

2.2.1 To which homologous series does compound **D** belong? (1)

2.2.2 Write down the STRUCTURAL FORMULA and IUPAC NAME of a structural isomer of compound **D**. (4)

2.2.3 Is the isomer in QUESTION 2.2.2 a CHAIN, POSITIONAL or FUNCTIONAL isomer? (1)

2.3 Compound **D** reacts with bromine (Br_2) to form 2-bromobutane.

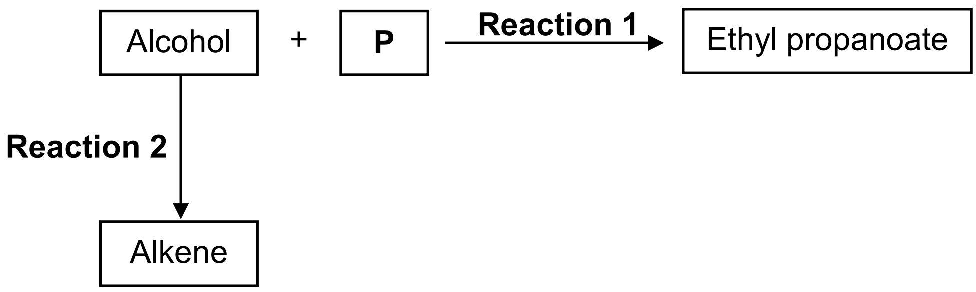
Write down the name of the:

2.3.1 Homologous series to which 2-bromobutane belongs (1)

2.3.2 Type of reaction that takes place (1)
[16]

QUESTION 3 (Start on a new page.)

3.1 The flow diagram below shows two organic reactions. The letter **P** represents an organic compound.



Use the information in the flow diagram to answer the questions that follow.

Write down the:

3.1.1 Type of reaction of which **Reaction 1** is an example (1)

3.1.2 STRUCTURAL FORMULA of the functional group of ethyl propanoate (1)

3.1.3 IUPAC name of compound **P** (1)

Reaction 2 takes place in the presence of an acid catalyst and heat.

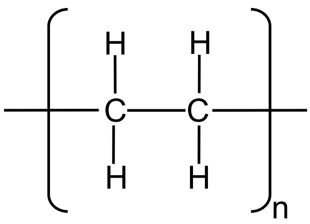
Write down the:

3.1.4 Type of reaction of which **Reaction 2** is an example (1)

3.1.5 NAME or FORMULA of the acid catalyst (1)

3.1.6 STRUCTURAL FORMULA of the alkene (2)

3.2 The condensed formula of a polymer is shown below.



Write down the:

3.2.1 STRUCTURAL FORMULA of the monomer that is used to prepare the above polymer (2)

3.2.2 Type of polymerisation reaction (ADDITION or CONDENSATION) that is used to prepare this polymer (1)

[10]

QUESTION 4 (Start on a new page.)

Four compounds of comparable molecular mass are used to investigate the effect of functional groups on vapour pressure. The results obtained are shown in the table below.

COMPOUND		**VAPOUR PRESSURE (kPa at 20 °C)**
A	Butane	204
B	Propan-2-one	24,6
C	Propan-1-ol	2
D	Ethanoic acid	1,6

4.1 Define the term *functional group* of an organic compound. (2)

4.2 Which ONE of the compounds (**A**, **B**, **C** or **D**) in the table has the:

4.2.1 Highest boiling point
(Refer to the vapour pressures in the table to give a reason for the answer.) (2)

4.2.2 Weakest intermolecular forces (1)

4.3 Refer to the type of intermolecular forces to explain the difference between the vapour pressure of compound **A** and compound **B**. (3)

4.4 The vapour pressures of compounds **C** and **D** are much lower than those of compounds **A** and **B**. Name the type of intermolecular force in **A** and **B** that is responsible for this difference. (1)

4.5 Briefly explain the difference in vapour pressure between compound **C** and compound **D**. (2)

4.6 During a combustion reaction in a closed container of adjustable volume, 8 cm^3 of compound **A** (butane) reacts in excess oxygen according to the following balanced equation:

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$$

If the initial volume of the oxygen in the container was 60 cm^3, calculate the TOTAL volume of the gases that are present in the container at the end of the reaction. All the gases in the container are at the same temperature and pressure. (5)

[16]

QUESTION 5 (Start on a new page.)

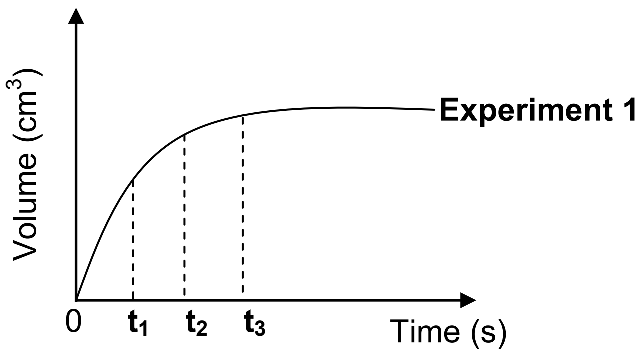
Dilute acids, indicated in the table below, react with EXCESS zinc in each of the three experiments to produce hydrogen gas. The zinc is completely covered with the acid in each experiment.

EXPERIMENT	DILUTE ACID
1	100 cm^3 of 0,1 $mol{\cdot}dm^{-3}$ H_2SO_4
2	50 cm^3 of 0,2 $mol{\cdot}dm^{-3}$ H_2SO_4
3	100 cm^3 of 0,1 $mol{\cdot}dm^{-3}$ $HC\ell$

The volume of hydrogen gas produced is measured in each experiment.

5.1 Name TWO essential apparatuses needed to determine the rate of hydrogen production. (2)

The graph below was obtained for **Experiment 1**.



Use this graph and answer the questions that follow.

5.2 At which time ($\mathbf{t_1}$, $\mathbf{t_2}$ or $\mathbf{t_3}$) is the:

5.2.1 Reaction rate the highest (1)

5.2.2 Mass of zinc present in the flask the smallest (1)

5.3 In which time interval, **between t_1 and t_2** OR **between t_2 and t_3**, does the largest volume of hydrogen gas form per second? (1)

5.4 Redraw the graph for **Experiment 1** in the ANSWER BOOK.

On the same set of axes, sketch the graphs that will be obtained for **Experiments 2** and **3**. Clearly label the three graphs as **EXPERIMENT 1**, **EXPERIMENT 2** and **EXPERIMENT 3**. (4)

5.5 The initial mass of zinc used in each experiment is 0,8 g. The balanced equation for the reaction in **Experiment 3** is:

$$Zn(s) + 2HC\ell(aq) \rightarrow ZnC\ell_2(aq) + H_2(g)$$

5.5.1 Calculate the mass of zinc present in the flask after completion of the reaction in **Experiment 3**. (5)

5.5.2 How will the mass of zinc present in the flask after completion of the reaction in **Experiment 2** compare to the answer to QUESTION 5.5.1? Write down only LARGER THAN, SMALLER THAN or EQUAL TO. (1)

[15]

QUESTION 6 (Start on a new page.)

An unknown gas, $X_2(g)$, is sealed in a container and allowed to form $X_3(g)$ at 300 °C. The reaction reaches equilibrium according to the following balanced equation:

$$3X_2(g) \rightleftharpoons 2X_3(g)$$

6.1 How will the rate of formation of $X_3(g)$ compare to the rate of formation of $X_2(g)$ at equilibrium? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

The reaction mixture is analysed at regular time intervals. The results obtained are shown in the table below.

TIME (s)	**[X_2] ($mol \cdot dm^{-3}$)**	**[X_3] ($mol \cdot dm^{-3}$)**
0	0,4	0
2	0,22	0,120
4	0,08	0,213
6	0,06	0,226
8	0,06	0,226
10	0,06	0,226

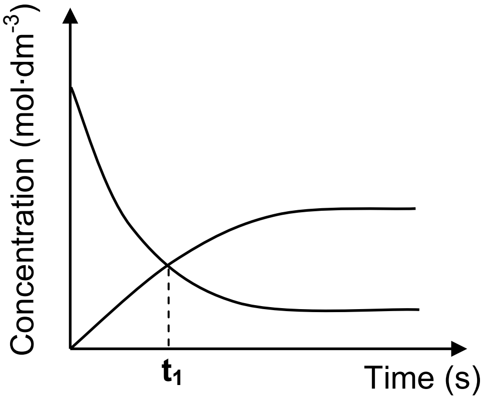
6.2 Calculate the equilibrium constant, K_c, for this reaction at 300 °C. (4)

6.3 More $X_3(g)$ is now added to the container.

6.3.1 How will this change affect the amount of $X_2(g)$? Write down INCREASES, DECREASES or REMAINS THE SAME. (1)

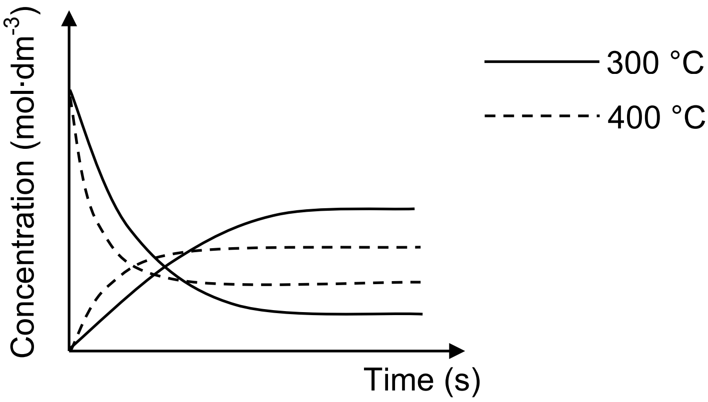
6.3.2 Use Le Chatelier's principle to explain the answer to QUESTION 6.3.1. (2)

The curves on the set of axes below (not drawn to scale) was obtained from the results in the table on page 10.



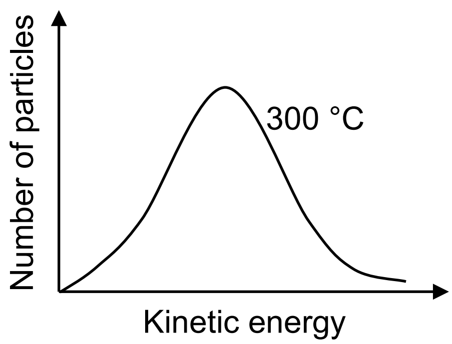
6.4 How does the rate of the forward reaction compare to that of the reverse reaction at $\mathbf{t_1}$? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

The reaction is now repeated at a temperature of 400 °C. The curves indicated by the dotted lines below were obtained at this temperature.



6.5 Is the forward reaction EXOTHERMIC or ENDOTHERMIC? Fully explain how you arrived at the answer. (4)

The Maxwell-Boltzmann distribution curve below represents the number of particles against kinetic energy at 300 °C.



6.6 Redraw this curve in the ANSWER BOOK. On the same set of axes, sketch the curve that will be obtained at 400 °C. Clearly label the curves as **300 °C** and **400 °C** respectively. (2)
[15]

QUESTION 7 (Start on a new page.)

7.1 Ammonium chloride crystals, $NH_4C\ell(s)$, dissolve in water to form ammonium and chloride ions. The ammonium ions react with water according to the balanced equation below:

$$NH_4^+(aq) + H_2O(\ell) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$$

7.1.1 Write down the name of the process described by the underlined sentence. (1)

7.1.2 Is ammonium chloride ACIDIC or BASIC in aqueous solution? Give a reason for the answer. (2)

7.2 A certain fertiliser consists of 92% ammonium chloride. A sample of mass x g of this fertiliser is dissolved in 100 cm^3 of a 0,10 $mol{\cdot}dm^{-3}$ sodium hydroxide solution, NaOH(aq). The NaOH is in excess.

The balanced equation for the reaction is:

$$NH_4C\ell(s) + NaOH(aq) \rightarrow NH_3(g) + H_2O(\ell) + NaC\ell(aq)$$

7.2.1 Calculate the number of moles of sodium hydroxide in which the sample is dissolved. (3)

During a titration, 25 cm^3 of the excess sodium hydroxide solution is titrated with a 0,11 $mol{\cdot}dm^{-3}$ hydrochloric acid solution, $HC\ell(aq)$. At the endpoint it is found that 14,55 cm^3 of the hydrochloric acid was used to neutralise the sodium hydroxide solution according to the following balanced equation:

$$HC\ell(aq) + NaOH(aq) \rightarrow NaC\ell(aq) + H_2O(\ell)$$

7.2.2 Calculate the mass x (in grams) of the fertiliser sample used. (8)

7.3 Calculate the pH of a 0,5 $mol{\cdot}dm^{-3}$ sodium hydroxide solution at 25 °C. (4)

[18]

QUESTION 8 (Start on a new page.)

Learners are given the following two unknown half-cells:

Half-cell 1: Q^{2+} (aq) | Q(s)

Half-cell 2: Pt | R_2(g) | R^-(aq)

During an investigation to identify the two half-cells, the learners connect each half-cell alternately to a Cd^{2+}(aq) | Cd(s) half-cell under standard conditions. For each combination of two half-cells, they write down the net cell reaction and measure the cell potential.

The results obtained for the two half-cell combinations are given in the table below.

COMBINATION	NET CELL REACTION	CELL POTENTIAL
I	$\mathbf{Q}^{2+}$(aq) + Cd(s) → Cd^{2+}(aq) + **Q**(s)	0,13 V
II	$\mathbf{R}_2$(g) + Cd(s) → Cd^{2+}(aq) + 2$\mathbf{R}^-$(aq)	1,76 V

8.1 Write down THREE conditions needed for these cells to function as standard cells. (3)

8.2 For **Combination I**, identify:

8.2.1 The anode of the cell (1)

8.2.2 **Q** by using a calculation (5)

8.3 For **Combination II**, write down the:

8.3.1 Oxidation half-reaction (2)

8.3.2 NAME or FORMULA of the metal used in the cathode compartment (1)

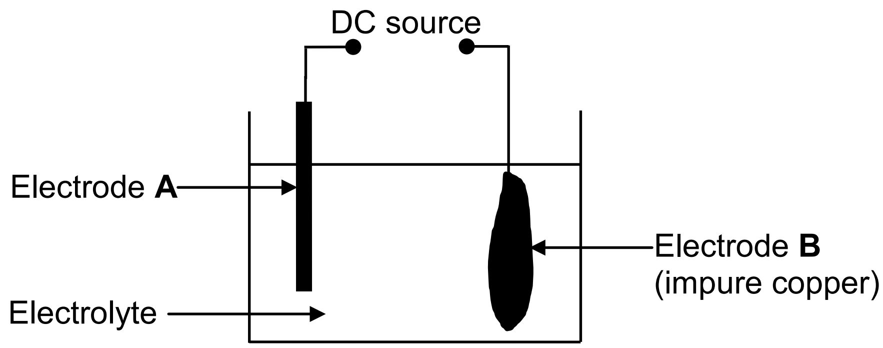
8.4 Arrange the following species in order of INCREASING oxidising ability:

Q^{2+} ; R_2 ; Cd^{2+}

Explain fully how you arrived at the answer. A calculation is NOT required. (4)
[16]

QUESTION 9 (Start on a new page.)

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



9.1 Define the term *electrolysis*. (2)

9.2 Give a reason why a direct-current (DC) source is used in this experiment. (1)

9.3 Write down the half-reaction which takes place at electrode **A**. (2)

9.4 Due to small amounts of zinc impurities in the impure copper, the electrolyte becomes contaminated with Zn^{2+} ions.

Refer to the attached Table of Standard Reduction Potentials to explain why the Zn^{2+} ions will not influence the purity of the copper obtained during this process. (3)

9.5 After the purification of the impure copper was completed, it was found that $2,85 \times 10^{-2}$ moles of copper were formed.

The initial mass of electrode **B** was 2,0 g. Calculate the percentage of copper that was initially present in electrode **B**. (4)
[12]

QUESTION 10 (Start on a new page.)

Ammonia is an important fertiliser. Large amounts are prepared from hydrogen and nitrogen in industry.

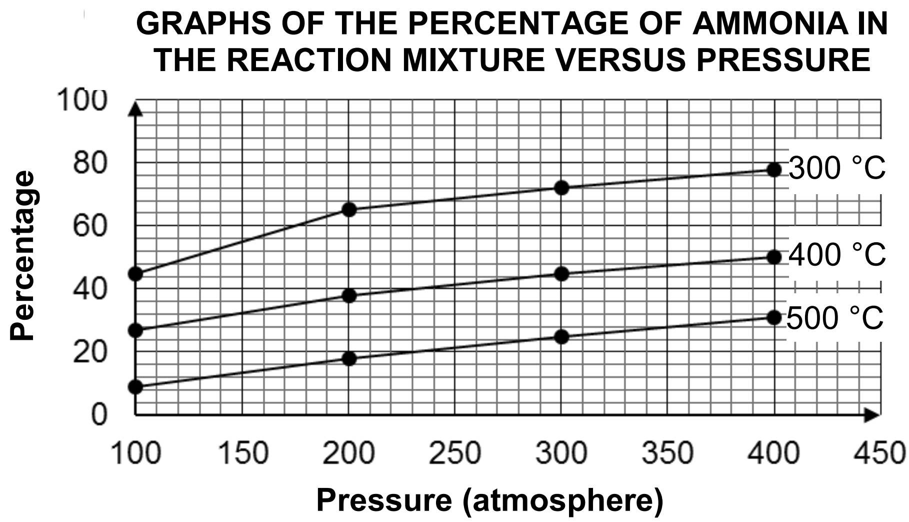
10.1 For the industrial preparation of ammonia, write down:

10.1.1 The name of the process used (1)

10.1.2 A balanced equation for the reaction that occurs (3)

10.1.3 The source of nitrogen (1)

10.2 The yield of ammonia changes with temperature and pressure during its industrial preparation. The graphs below show how the percentage of ammonia in the reaction mixture that leaves the reaction vessel varies under different conditions.



10.2.1 Use the appropriate graph to estimate the percentage of ammonia present in the reaction mixture at 240 atmosphere and 400 °C. (1)

10.2.2 State TWO advantages of using high pressure in the preparation of ammonia. (2)

10.2.3 The advantage of using a low temperature is the large percentage of ammonia formed. What is the disadvantage of using a low temperature? (1)

10.3 Ammonia is also used in the preparation of other fertilisers such as ammonium nitrate. Calculate the mass of nitrogen in a 50 kg bag of pure ammonium nitrate fertiliser. (3)

[12]

TOTAL: 150

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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* $E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	

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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**

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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)
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 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
$\mathbf{2H^+ + 2e^-}$	$\rightleftharpoons$	$\mathbf{H_2(g)}$	**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

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

Increasing oxidising ability/*Toenemende oksiderende vermoë*

Increasing reducing ability/*Toenemende reduserende vermoë*

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

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