basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 11

PHYSICAL SCIENCES: CHEMISTRY (P2)

EXEMPLAR 2013

MARKS: 150

TIME: 3 hours

This question paper consists of 13 pages, 1 data sheet and a periodic table.

INSTRUCTIONS AND INFORMATION

1. Write your name in the appropriate space on the ANSWER BOOK.

2. This question paper consists of TWELVE questions. Answer ALL the questions in the ANSWER BOOK.

3. You may use a non-programmable calculator.

4. You may use appropriate mathematical instruments.

5. YOU ARE ADVISED TO USE THE ATTACHED DATA SHEETS.

6. Number the answers correctly according to the numbering system used in this question paper.

7. 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. Write only the letter (A–D) next to the question number (2.1–2.10) in the ANSWER BOOK.

1.1 Which ONE of the following chlorides will most likely have the most ionic character?

A $LiC\ell$

B $CsC\ell$

C $BeC\ell_2$

D $CaC\ell_2$ (2)

1.2 The molecular shape of a molecule with the formula AB_2 is …

A linear or bent.

B linear or trigonal planar.

C linear or tetrahedral.

D linear or trigonal bipyramidal. (2)

1.3 The boiling point of CH_4 is much lower than that of HF. Which ONE of the following best explains this difference in boiling points?

A HF molecules are more polar than CH_4 molecules.

B CH_4 molecules are more polar than HF molecules.

C There are hydrogen bonds between HF molecules.

D There are dipole-dipole forces between CH_4 molecules. (2)

1.4 The temperature (in kelvin) of a fixed mass of an enclosed gas is given as T.

Which ONE of the following CORRECTLY represents the new temperature if both the pressure and the volume of the gas are doubled?

A ¼T

B ½T

C 2T

D 4T (2)

1.5 According to the kinetic-molecular theory, molecules of different gases at the same temperature always have the same …

A pressure.

B volume.

C kinetic energy.

D average kinetic energy. (2)

1.6 Which ONE of the following statements about a chemical reaction is CORRECT?

The actual yield of a chemical reaction is usually …

A equal to the percentage yield.

B greater than the percentage yield.

C less than the theoretical yield.

D greater than the theoretical yield. (2)

1.7 Which ONE of the following statements is CORRECT for an endothermic reaction?

A The temperature of the surroundings increases.

B The enthalpy change for the reaction is negative.

C Heat flows from the surroundings into the system.

D The enthalpy of products is less than the enthalpy of reactants. (2)

1.8 Consider the incomplete chemical equation below.

$\mathbf{X} + 2HNO_3 \rightarrow Zn(NO_3)_2 + H_2O + CO_2$

Which ONE of the following is represented by **X** in the above equation?

A $ZnCO_3$

B $ZnHCO_3$

C $ZnCO_2$

D $Zn(OH)_2$ (2)

1.9 Consider the reaction represented by the balanced ionic equation below.

$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 3S^{2-}(aq) \rightarrow 2Cr^{3+}(aq) + 3S(s) + 7H_2O(\ell)$

When this reaction takes place, …

A the oxidation number of sulphur does not change.

B S^{2-} is reduced by the $Cr_2O_7^{2-}(aq)$.

C $H^+(aq)$ oxidises the $S^{2-}(aq)$.

D $S^{2-}(aq)$ is oxidised by the $Cr_2O_7^{2-}(aq)$. (2)

1.10 Gold can be made into thin sheets that are used for decoration.

The property of gold illustrated by the above statement is that gold …

A is a good conductor of electricity.

B has a high density.

C is malleable.

D is a good conductor of heat. (2)
[20]

QUESTIONS 2–12

INSTRUCTIONS AND INFORMATION

1. Start EACH question on a NEW page in the ANSWER BOOK.

2. Leave ONE line between two subquestions, for example between QUESTION 2.1 and QUESTION 2.2.

3. Show ALL formulae and substitutions in ALL calculations.

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

5. Give brief motivations, discussions, et cetera where required.

QUESTION 2 (Start on a new page.)

Ammonia (NH_3) is an important gas used in the preparation of fertilisers. An ammonia molecule is formed when electrons are shared between three hydrogen atoms and a nitrogen atom.

2.1 Name the type of chemical bond formed between a hydrogen and a nitrogen atom. (1)

2.2 How many valence electrons does a nitrogen atom have? (1)

2.3 Write down a Lewis structure for the ammonia molecule. (2)

2.4 For the ammonia molecule, write down the:

2.4.1 Number of electron pairs surrounding the central atom (1)

2.4.2 Number of atoms surrounding the central atom (1)

2.4.3 Name used to describe the molecular shape (1)

Ammonia dissolves readily in water to form ammonium ions, NH_4^+(aq). An ammonium ion is formed when an ammonia molecule shares a lone pair of electrons with a hydrogen ion.

2.5 Name the type of bond formed between an ammonia molecule and a hydrogen ion. (1)

2.6 Represent the formation of an ammonium ion with the aid of Lewis structures. (4)

2.7 For the ammonium ion, write down the:

2.7.1 Number of atoms surrounding the central atom (1)

2.7.2 Name used to describe the molecular shape (1)

The nitrogen atom can also bond with itself to form the nitrogen molecule.

2.8 Which ONE of the following bonds will be the strongest?

I: Bond between a nitrogen atom and a hydrogen atom
OR
II: Bond between a nitrogen atom and a nitrogen atom

Write down **I** or **II**. Give a reason for the answer. (2)
[16]

QUESTION 3 (Start on a new page.)

The table below shows the boiling points of the hydrides of group IV (compounds in which hydrogen is bonded to elements from group IV in the periodic table).

BOILING POINTS OF HYDRIDES FROM GROUP IV

HYDRIDES OF GROUP IV	RELATIVE MOLECULAR MASS	BOILING POINT (°C)
CH_4	16	–164
SiH_4	32	–112
GeH_4	77	–89
SnH_4	123	–52

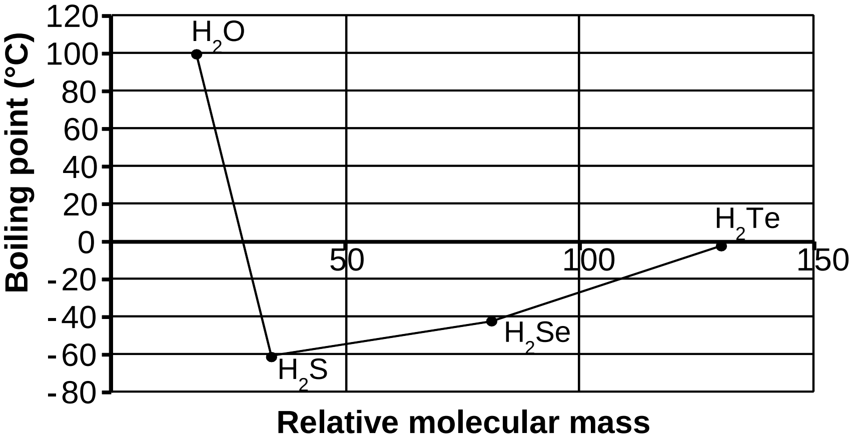
3.1 What is the phase (solid, liquid or gas) of the hydrides above at 25 °C? (1)

3.2 Name the type of Van der Waals forces between molecules of the hydrides in the table above. (1)

3.3 Explain the trend in boiling points observed for the hydrides in the above table. In your explanation, refer to molecular size, intermolecular forces and the energy needed. (3)

The graph below shows the boiling points of the hydrides of group VI in the periodic table versus their relative molecular masses.

GRAPH OF BOILING POINT VERSUS RELATIVE MOLECULAR MASS



3.4 From the graph above, deduce and then write down the NAME of the hydride:

3.4.1 With the weakest intermolecular forces (1)

3.4.2 With hydrogen bonds between molecules (1)

3.4.3 That requires the most energy to undergo a phase change (1)

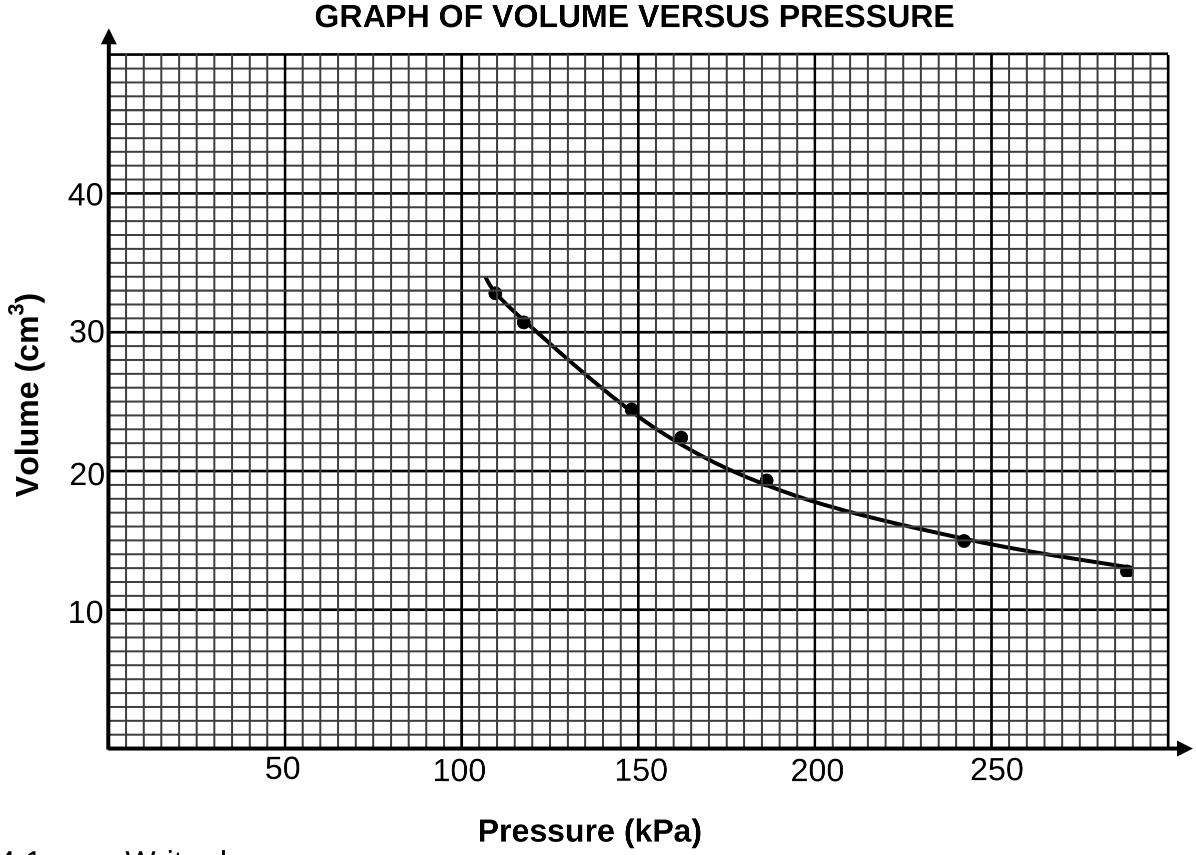
3.5 Refer to intermolecular forces and energy and give a reason why one of the hydrides of group VI deviates from the trend in boiling point observed for the others. (2)

[10]

QUESTION 4 (Start on a new page.)

A fixed mass of oxygen is used to verify one of the gas laws. The results obtained are shown in the graph below.

GRAPH OF VOLUME VERSUS PRESSURE



4.1 Write down:

4.1.1 A mathematical expression, in symbols, for the relationship between the variables shown in the graph (1)

4.1.2 The name of the gas law investigated (1)

4.1.3 Explain the relationship in QUESTION 4.1.1 in terms of the kinetic theory of gases. (2)

4.2 Write down TWO variables that must be kept constant during this investigation and briefly describe how this is done. (4)

4.3 From the graph, write down the volume of oxygen, in cm^3, when the pressure is 120 kPa. (2)

4.4 Calculate the pressure, in kPa, exerted on the gas when it is compressed to 5 cm^3. (4)

4.5 Write down TWO conditions under which oxygen gas will deviate from ideal gas behaviour. (2)

[16]

QUESTION 5 (Start on a new page.)

The reaction between calcium hydride (CaH_2) and water is often used to inflate weather balloons. The reaction produces hydrogen gas according to the following balanced equation:

$$CaH_2(s) + 2H_2O(\ell) \rightarrow Ca(OH)_2(aq) + 2H_2(g)$$

5.1 Calculate the mass of calcium hydride needed to generate 53,3 dm^3 of hydrogen gas at a pressure of 108 kPa and a temperature of 21 °C. (8)

5.2 How will the answer to QUESTION 5.1 change if the same volume of gas is produced at the same pressure, but at a lower temperature? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

[9]

QUESTION 6 (Start on a new page.)

Consider the reaction represented by the equation below.

$$CO_2(g) + 2H_2O(\ell) \rightarrow CH_4(g) + 2O_2(g)$$

During the reaction the temperature of the reaction mixture decreases.

6.1 Define the term *enthalpy change*. (2)

6.2 Does the enthalpy change (ΔH) for this reaction have a positive or negative value? Explain the answer by referring to the energy involved. (2)

6.3 Sketch a labelled potential energy graph for this reaction. On the graph, show the position of the reactants, products, ΔH and activation energy. (6)

[10]

QUESTION 7 (Start on a new page.)

The airbags in motor vehicles contain the compound sodium azide (NaN_3). When a car crashes into an object, the compound decomposes and the nitrogen inflates the airbag. The balanced equation for the reaction is as follows:

$$NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$$

In one such decomposition, 2,53 x 10^8 molecules of nitrogen are generated.

Calculate the:

7.1 Number of moles of $NaN_3(s)$ that decomposed (4)

7.2 Volume of $N_2(g)$ produced
Assume that the reaction occurs at standard pressure. (3)
[7]

QUESTION 8 (Start on a new page.)

Aluminium sulphate is used as a coagulant in water purification. It reacts with sodium hydroxide to form aluminium hydroxide which drags the impurities as it settles.

The balanced equation for the reaction is:

$$A\ell_2(SO_4)_3(aq) + 6NaOH(aq) \rightarrow 2A\ell(OH)_3(s) + 3Na_2SO_4(aq)$$

A chemist at a water purification plant adds 700 g of $A\ell_2(SO_4)_3$ to a sample of water.

8.1 Calculate the maximum mass of $A\ell(OH)_3$ that can be produced from this mass of $A\ell_2(SO_4)_3$. (5)

The chemist now dissolves 0,85 mol of Na_2SO_4 in 250 cm^3 of distilled water. He then tops it up with enough distilled water to make a 1 litre solution.

8.2 Define, in words, the term *concentration of a solution*. (2)

8.3 Calculate the concentration of this Na_2SO_4 solution. (3)
[10]

QUESTION 9 (Start on a new page.)

The chemical reaction for the production of the drug, aspirin, from two compounds, **X** and **Y**, is represented by the balanced equation below.

$$\underset{\mathbf{X}}{2C_7H_6O_3} + \underset{\mathbf{Y}}{C_4H_6O_3} \rightarrow \underset{\text{aspirin}}{2C_9H_8O_4} + H_2O$$

A chemist reacts 14 g of compound **X** with 10 g of compound **Y**.

9.1 Define the term *limiting reactant* in a chemical reaction. (2)

9.2 Perform the necessary calculations to determine which one of compound **X** or compound **Y** is the limiting reactant. (5)

The actual mass of aspirin obtained is 11,5 g.

9.3 Calculate the percentage yield of the aspirin. (5)
[12]

QUESTION 10 (Start on a new page.)

Acids and bases can be defined in terms of the following two theories:

I: Arrhenius theory
II: Lowry-Brönsted theory

10.1 According to the Arrhenius theory, sodium hydroxide is classified as a base.

Write down the chemical formula of the ion responsible for the basic properties of sodium hydroxide. (1)

10.2 Consider the reaction represented by the incomplete equation below:

$$HNO_3(aq) + OH^-(aq) \rightleftharpoons \_\_\_\_\_ + \_\_\_\_\_$$

10.2.1 Use your knowledge of the Lowry-Brönsted theory to write a balanced equation for this reaction. (3)

10.2.2 Write down the formulae of ONE conjugate acid-base pair in this reaction. (2)

10.3 In a reaction, 40 cm^3 of nitric acid neutralises 25 cm^3 of a 0,05 $mol{\cdot}dm^{-3}$ solution of barium hydroxide according to the following balanced equation:

$$2HNO_3(aq) + Ba(OH)_2(aq) \rightarrow Ba(NO_3)_2(aq) + 2H_2O(\ell)$$

Calculate the:

10.3.1 Number of moles of base that reacted (2)

10.3.2 Number of moles of acid that reacted (1)

10.3.3 Concentration of the acid (2)
[11]

QUESTION 11 (Start on a new page.)

Redox reactions can be explained in terms of electron transfer as well as oxidation numbers.

The unbalanced equations **A**, **B** and **C** below represent three redox reactions.

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

B: $NiO(s) + CO(g) \rightarrow Ni(s) + CO_2(g)$

C: $Cu(s) + HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + NO(g) + H_2O(\ell)$

11.1 Define o*xidation* in terms of electron transfer. (2)

11.2 Write down the formula of the substance which is:

11.2.1 Oxidised in reaction **A** (1)

11.2.2 The reducing agent in reaction **B**
Explain the answer in terms of oxidation numbers. (3)

11.3 For reaction **C**, write down the balanced equation using the ion-electron method. Show the oxidation and reduction half-reactions during the balancing. (5)
[11]

QUESTION 12 (Start on a new page.)

The flow diagram below illustrates the first step in the recovery of gold.

$$\boxed{\text{Gold}} \xrightarrow{\textbf{A}} \boxed{NaAu(CN)_2}$$

12.1 The reaction taking place during process **A** is:

$$Au(s) + NaCN(aq) + O_2(g) + 2H_2O(\ell) \rightarrow 4NaAu(CN)_2(aq) + 4NaOH(aq)$$

12.1.1 Balance the above equation. (2)

12.1.2 Write down the name of the process labelled **A**. (1)

12.1.3 What type of reaction takes place during process **A**?

Write down only PRECIPITATION, ACID-BASE or REDOX. (1)

12.1.4 Will the solution formed during process **A** be ACIDIC, NEUTRAL or BASIC?

Refer to the equation to give a reason for the answer. (2)

12.1.5 Give ONE reason why this process is considered to be potentially harmful. (1)

12.2 The second step in the recovery of gold is illustrated below.

$$\boxed{NaAu(CN)_2} \xrightarrow{\textbf{B}} \boxed{\text{Gold}}$$

12.2.1 Write down the name of the process labelled **B**. (1)

12.2.2 Is the metal used in process **B** an ALKALI, ALKALI EARTH or TRANSITION metal? (1)

12.2.3 Is the metal in QUESTION 12.2.2 more reactive or less reactive than gold? (1)

12.3 The mining of gold and its recovery from the ore has advantages and disadvantages.

12.3.1 Give TWO reasons why the gold mining industry is so important to the South African economy. (2)

12.3.2 Write down TWO negative impacts that the gold mining industry has on the environment. (2)

12.4 A new gold reef is discovered in South Africa.

Write down TWO factors which have to be considered before developing the site for mining. (4)
[18]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 11
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 11
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Avogadro's constant *Avogadro-konstante*	N_A	$6,02 \times 10^{23}$ mol^{-1}
Molar gas constant *Molêre gaskonstante*	R	8,31 J·K^{-1}·mol^{-1}
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·mol^{-1}
Standard temperature *Standaardtemperatuur*	T^θ	273 K

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$	$pV = nRT$
$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$n = \frac{V}{V_m}$	$c = \frac{n}{V}$ OR/*OF* $c = \frac{m}{MV}$

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

KEY/*SLEUTEL*

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