basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

NOVEMBER 2010

MEMORANDUM

MARKS: 150

This memorandum consists of 16 pages.

Learning Outcomes and Assessment Standards		
LO 1	**LO 2**	**LO 3**
AS 12.1.1: Design, plan and conduct a scientific inquiry to collect data systematically with regard to accuracy, reliability and the need to control variables. **AS 12.1.2:** Seek patterns and trends, represent them in different forms, explain the trends, use scientific reasoning to draw and evaluate conclusions, and formulate generalisations. **AS 12.1.3:** Select and use appropriate problem-solving strategies to solve (unseen) problems. **AS 12.1.4:** Communicate and defend scientific arguments with clarity and precision.	**AS 12.2.1:** Define, discuss and explain prescribed scientific knowledge. **AS 12.2.2** Express and explain prescribed scientific principles, theories, models and laws by indicating the relationship between different facts and concepts in own words. **AS 12.2.3:** Apply scientific knowledge in everyday life contexts.	**AS 12.3.1:** Research, discuss, compare and evaluate scientific and indigenous knowledge systems and knowledge claims by indicating the correlation among them, and explain the acceptance of different claims. **AS 12.3.2:** Research case studies and present ethical and moral arguments from different perspectives to indicate the impact (pros and cons) of different scientific and technological applications. **AS 12.3.3:** Evaluate the impact of scientific and technological research and indicate the contribution to the management, utilisation and development of resources to ensure sustainability continentally and globally.

GENERAL GUIDELINES

1. CALCULATIONS

1.1 Award marks for: correct formula, correct substitution, correct answer with unit.

1.2 Do no award any marks if an incorrect or inappropriate formula is used, even though there may be relevant symbols and applicable substitutions.

1.3 When an error is made during **substitution into a correct formula**, award a mark for the correct formula and for the correct substitutions, but **do not give any further marks**.

1.4 If no formula is given, but all substitutions are correct, the candidate forfeits one mark.

Example:
No K_c expression, correct substitution

$$K_c = \frac{(2)^2}{(2)(1)^3} \checkmark = 2 \checkmark (\frac{2}{3})$$

1.5 Marks can only be allocated for substitutions when values are substituted into formulae and not when listed before a calculation starts.

1.6 All calculations, when not specified in the question, must be done to two decimal places.

2. UNITS

2.1 Candidates must be penalised only once for the repeated use of an incorrect unit **within a question or subquestion**.

2.2 Units are only required in the final answer to a calculation.

2.3 Award marks for an answer only, and not for a unit *per se*. Candidates forfeit the mark allocated for the answer in each of the following situations:

- Correct answer + wrong unit
- Wrong answer + correct unit
- Correct answer + no unit

2.4 Separate compound units with a multiplication dot, not a full stop, for example, $mol \cdot dm^{-3}$. Accept $mol.dm^{-3}$ (or mol/dm^3) for marking purposes

3. GENERAL

3.1 If one answer or calculation is required, but the candidate gives two, mark only the first one, irrespective of which one is correct. If two answers are required, mark only the first two, etc.

3.2 When a chemical **FORMULA** is asked, and the **NAME** is given as answer the candidate forfeits the marks. The same rule applies when the **NAME** is asked and the **FORMULA** is given.

3.3 When redox half-reactions are to be written, the correct arrow should be used. If the equation

$$H_2S \rightarrow S + 2\,H^+ + 2e^- \quad (2/2)$$

is the correct answer, the marks must be given as follows:

$H_2S \rightleftharpoons S + 2\,H^+ + 2e^-$ $(1/2)$

$H_2S \leftarrow S + 2\,H^+ + 2e^-$ $(0/2)$

$S + 2H^+ + 2e^- \leftarrow H_2S$ $(2/2)$

$S + 2H^+ + 2e^- \rightleftharpoons H_2S$ $(0/2)$

3.4 When candidates are required to give an explanation involving the relative strength of oxidising and reducing agents, do not accept the following:

- Stating the position of a substance on table 4 only (e.g. Cu is above Mg).
- Using relative reactivity only (e.g. Mg is more reactive than Cu).
- The correct answer would be for instance: Mg is a stronger reducing agent than Cu, and therefore Mg will be able to reduce Cu^{2+} ions to Cu. The answer can also be given in terms of the relative strength as electron acceptors and donors.

3.5 One mark is forfeited when the charge of an ion is omitted per equation.(not for the charge on an electron)

3.6 The error carrying principle does not apply to chemical equations or half reactions. For example, if a learner writes the wrong oxidation/reduction half-reaction in the sub-question and carries the answer to another sub-question (balancing of equations or calculation of E^{θ}_{cell}) then the learner must not be credited for this substitution.

3.7 In the structural formula of an organic molecule all hydrogen atoms must be shown. Marks must be deducted if hydrogen atoms are omitted.

3.8 When a structural formula is asked, marks must be deducted if the learner writes the condensed formula.

3.9 When an IUPAC name is asked and the candidate omits the hyphen (e.g. instead of pent-1-ene or 1-pentene the candidate writes pent 1 ene or 1 pentene), marks must be forfeited.

3.10 When a chemical reaction is asked, marks are awarded for correct reactants, correct products and correct balancing.

3.11 If only a reactant(s) followed by an arrow, or only a product(s) preceded by an arrow, is/are written, marks may be awarded for the reactant(s) or product(s). If only a reactant(s) or only a product(s) are written, without an arrow, no marks are awarded for the reactant(s) or product(s).

Examples: $N_2 + 3H_2$ ✓→ $2NH_3$ ✓ bal. ✓

$N_2 + H_2$ →✓	$1/3$
→ NH_3 ✓	$1/3$
$N_2 + H_2$	$0/3$
NH_3	$0/3$

4. POSITIVE MARKING

Positive marking regarding calculations is followed in the following cases:

4.1 **Subquestion to subquestion:** When a certain variable is calculated in one sub-question (e.g. 3.1) and needs to be substituted in another (3.2 or 3.3), e.g. if the answer for 3.1 is incorrect and is substituted correctly in 3.2 or 3.3, **full marks must** be awarded for the subsequent sub-questions.

4.2 **A multi-step question in a subquestion**: If the candidate has to calculate, for example, the number of moles in the first step and gets it wrong due to a substitution error, the mark for the substitution and the final answer is forfeited.

4.3 If a final answer to a calculation is correct, full marks are not automatically awarded. Markers must always ensure that the correct/appropriate formula is used and that workings, including substitutions, are correct.

SECTION A

QUESTION 1

1.1	Alkynes ✓	[12.2.1]	(1)
1.2	Cathode / Positive (electrode) ✓	[12.2.1]	(1)
1.3	Exothermic (reaction) ✓	[12.2.1]	(1)
1.4	Electrolytic (cell) ✓	[12.2.1]	(1)
1.5	Eutrophication ✓	[12.2.1]	(1)
			[5]

QUESTION 2

2.1	A ✓✓	[12.2.3]	(2)
2.2	B ✓✓	[12.2.3]	(2)
2.3	C ✓✓	[12.2.3]	(2)
2.4	D ✓✓	[12.1.2]	(2)
2.5	B ✓✓	[12.1.2]	(2)
2.6	D ✓✓	[12.2.3]	(2)
2.7	B ✓✓	[12.1.2]	(2)
2.8	B ✓✓	[12.2.3]	(2)
2.9	A ✓✓	[12.2.3]	(2)
2.10	C ✓✓	[12.2.1]	(2)
			[20]

TOTAL SECTION A: 25

SECTION B

QUESTION 3

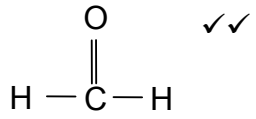
3.1 3.1.1 A ✓ [12.2.3] (1)

3.1.2 D ✓ [12.2.3] (1)

3.2 3.2.1 1-bromo-2-methylpropane ✓✓ [12.2.3] (2)

3.2.2 2,4-dimethylhexane ✓✓ [12.2.3] (2)

3.3

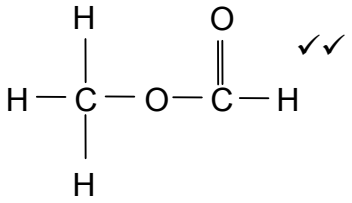


✓✓

[12.2.3] (2)

3.4 Ethanoic acid ✓✓ [12.2.1] (2)

3.5 `



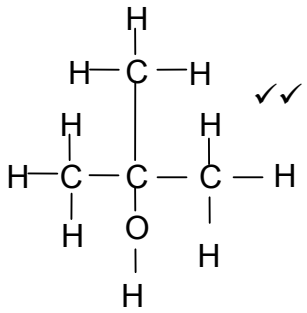
✓✓

[12.2.3] (2)
[12]

QUESTION 4

4.1 D ✓ [12.2.3] (1)

4.2.1



✓✓

[12.2.3] (2)

4.2.2 D ✓ [12.2.3] (1)

Criteria for investigative question	Mark
The dependent and independent variables are stated.	✓
Asks a question about the relationship between dependent and independent variables.	✓

4.3 4.3.1

Example:
What is the relationship between viscosity / flow time
and
chain length / number of C atoms / molecular mass / molecular size / molar mass / surface area / number of electrons / alcohols?
(or vice versa.) [12.1.1] (2)

4.3.2 C ✓
Longest flow time ✓ [12.1.2] [12.2.2] (2)

4.3.3 Increase in chain length / molecular mass / molar mass / molecular size / surface area from A to C. ✓

Increase in (strength of) intermolecular / Van der Waals / dispersion / London / forces ✓ [12.1.4] [12.2.2] (2)

4.3.4 C ✓ [12.3.2] (1)

4.4 D ✓ [12.1.2] (1)

4.5 The more branched /more compact /more spherical alcohol / E has a smaller surface area (over which the intermolecular forces act). ✓
Decrease in (strength of) intermolecular forces / Van der Waals / dispersion / London /forces ✓
reduces resistance to flow (and thus lower viscosity). [12.2.2] (2)

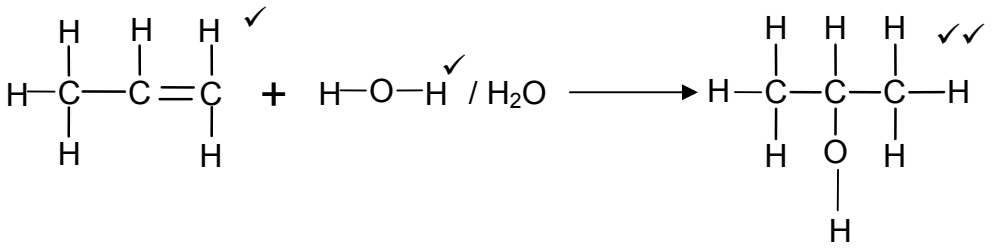
[14]

QUESTION 5

5.1 Any ONE: ✓
Prop-1-ene is highly flammable. [12.3.2] (1)

5.2 Any ONE: ✓
Alkenes contain a <u>double</u> carbon – carbon / (C=C) / bond.
The presence of the <u>pi bond</u>.
They are <u>unsaturated</u>.
Contains an <u>sp^2 hybridised C atom</u>.
All the <u>carbon atoms are not bonded to the max. number of atoms</u>. [12.2.1] (1)

5.3.1



[12.2.3] (4)

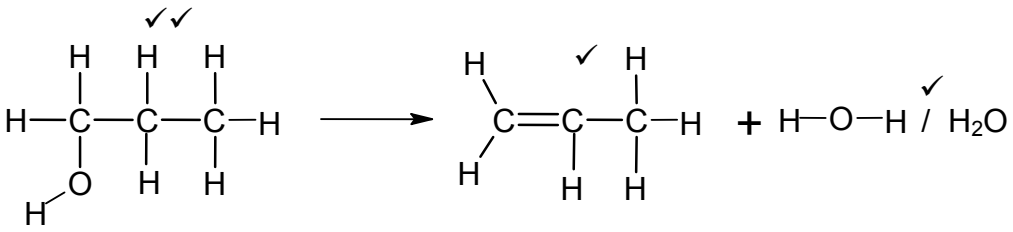
5.3.2 Hydration ✓ [12.2.1] (1)

5.3.3 Sulphuric acid/Hydrogen sulphate/H_2SO_4/Phosphoric acid / H_3PO_4 / Hydrogen phosphate✓ [12.2.1] (1)

5.4 $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

(reactants ✓ ; products✓ ; bal ✓) [12.2.3] (3)

5.5



[12.2.3] (4)

5.6 Dehydration ✓ [12.2.1] (1)
[16]

QUESTION 6

6.1 6.1.1 Catalyst ✓ [12.2.1] (1)

6.1.2 Effective collision ✓ [12.2.1] (1)

6.1.3 Surface area ✓ [12.2.1] (1)

6.1.4 Activated complex ✓ [12.2.1] (1)

6.1.5 Temperature ✓ [12.2.1] (1)

6.1.6 Heat of reaction ✓ [12.2.1] (1)

6.2 6.2.1

Criteria for hypothesis:	**Mark**
The dependent and independent variables are stated.	✓
Makes a prediction about the relationship between dependent and independent variables.	✓

Example:
Reaction rate increases with increase in temperature.

[12.1.1] (2)

6.2.2 Sulphur dioxide / SO_2 ✓ [12.1.1] (1)

6.2.3 Concentration / mass / mol ✓(of acid and sodium thiosulphate) [12.1.1] (1)

6.2.4 Sulphur / S ✓ [12.1.1] (1)

6.2.5 Different people have different sight abilities/reaction times.✓ [12.1.1] (1)

6.2.6 Reaction rate ✓ [12.1.2] (1)

6.2.7

Criteria for conclusion:	**Mark**
The dependent and independent variables are stated.	✓
Makes a correct /true statement about the relationship between dependent and independent variables obtained from the graph.	✓

Example:
Reaction rate increases with increase in temperature. [12.1.2] (2)

[15]

QUESTION 7

7.1 7.1.1 Fractional distillation of liquid air ✓ [12.2.1] (1)

7.1.2 $N_2 + 3H_2 \rightarrow 2NH_3$

(reactants ✓ products ✓ bal ✓) [12.2.3] (3)

7.1.3 Nitric acid / HNO_3 ✓ [12.2.1] (1)

7.1.4 $H_2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4$

(reactants ✓ ; products✓ ; bal ✓) [12.2.3] (3)

7.1.5 Nitrogen / N ✓ [12.2.1] (1)

7.2 Any ONE:

- Enhance growth of crops/plants ✓ to produce more food for humans /food security for humans.✓
- Production/application of fertiliser ✓ results in job creation.✓
- Selling of fertilisers ✓ stimulates the economy. ✓ [12.3.2] (2)

7.3 Any TWO:

- (Excessive) nitrates in water (eutrophication) ✓ can result in blue-baby syndrome / cancer. ✓
- (Excessive) nitrates/ammonium ions in water ✓can result in poor quality drinking water. ✓
- (Excessive) nitrates / ammonium ions in water cause death of fish (eutrophication)✓ can result in less food. ✓
- (Excessive) nitrates /ammonium ions in water (eutrophication)✓ can result in poorer water recreational facilities. ✓
- (Excessive) nitrates in soil kill plants/crops✓ resulting in food shortages/famine. ✓
- (Excessive) ammonium ions in soil increases the acidity of the soil ✓ limiting food production✓. [12.3.2] (4)

7.4 7.4.1 Increases ✓✓ [12.2.3] (2)

7.4.2 Decreases✓✓ [12.2.3] (2)

7.5

Option 1:

	SO_2	O_2	SO_3	
Molar ratio	2	1	2	
Initial quantity (mol)	4	$\frac{x}{32}$ ✓✓	0	
Change (mol)	3	1,5	3	Ratio ✓
Quantity at equilibrium (mol)	1	$\frac{x}{32}$ - 1,5 ✓	3✓	
Concentration (mol·dm^{-3})	0,5	$\frac{x-48}{64}$	1,5	Divide by 2 ✓

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]} \checkmark \therefore 4,5 = \frac{(1,5)^2}{(0,5)^2(\frac{x-48}{64})} \checkmark \therefore x = 176 \text{ g} \checkmark$$

Option 2

$n(SO_3$ at equilibrium) = cV = (1,5)(2) = 3 mol ✓
$n(SO_2$ reacted) = $n(SO_3$ formed) = 3 mol
$n(O_2$ reacted) = ½ $n(SO_3$ formed) = 1,5 mol } Using ratio ✓

At equilibrium: $n(SO_2) = 4 - 3 = 1$ mol
$n(O_2) = (y - 1,5)$ mol } ✓
$n(SO_3) = 3$ mol

$c(SO_3) = 1,5$ mol·dm^{-3}

$c(SO_2) = \frac{n}{V} = \frac{1}{2} = 0,5$ mol·dm^{-3}
$c(O_2) = \frac{n}{V} = \frac{y-1,5}{2}$ mol·dm^{-3} } ✓ divide by 2

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]} \checkmark \therefore 4,5 = \frac{(1,5)^2}{(0,5)^2(\frac{y-1,5}{2})} \checkmark \therefore y = 5,5$$

$\therefore n(O_2) = 5,5$ mol $\therefore m(O_2) = nM = (5,5)\checkmark(32) \checkmark = 176$ g ✓

Option 3:

	SO_2	O_2	SO_3
Molar ratio	2	1	2
Initial quantity (mol)	4	y	0
Change (mol)	3	1,5	3
Quantity at equilibrium (mol)	1	y – 1,5 ✓	3✓
Concentration ($mol \cdot dm^{-3}$)	0,5	$\frac{y-1,5}{2}$	1,5

Ratio ✓

Divide by 2 ✓

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]} \checkmark \therefore 4,5 = \frac{(1,5)^2}{(0,5)^2(\frac{y-1,5}{2})} \checkmark \therefore y = 5,5$$

$\therefore n(O_2) = 5,5 \text{ mol} \therefore m(O_2) = nM = (5,5)\checkmark(32) \checkmark = 176 \text{ g} \checkmark$

Option 4

	SO_2	O_2	SO_3
Molar ratio	2	1	2
Initial quantity (mol)	4	y	0
Change (mol)	3	1,5	3
Quantity at equilibrium (mol)	1	4	3 ✓
Concentration ($mol \cdot dm^{-3}$)	0,5		1,5

Ratio ✓

Divide by 2 ✓

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]} \checkmark$$

$$= \frac{(1,5)^2}{(0,5)^2[O_2]} \checkmark$$

$\therefore [O_2] = 2 \text{ mol} \cdot \text{dm}^{-3}$

✓

$4 = y – 1,5 \quad \therefore y = 5,5$

$\therefore \quad \therefore n(O_2) = 5,5 \text{ mol}$

$\therefore m(O_2) = nM = (5,5)\checkmark(32) \checkmark = 176 \text{ g} \checkmark$

Option 5

	SO_2	O_2	SO_3
Molar ratio	2	1	2
Initial concentration ($mol \cdot dm^{-3}$)	$\frac{4}{2} = 2\checkmark$	$\frac{x}{32x2}$ ✓✓	0
Change in concentration ($mol \cdot dm^{-3}$)	1,5	0,75	1,5
Equilibrium concentration ($mol \cdot dm^{-3}$)	0,5	0,015625x – 0,75 ✓	1,5

Divide by 2 ✓

Ratio ✓

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]} \checkmark \therefore 4,5 = \frac{(1,5)^2}{(0,5)^2(0,015625x - 0,75)} \checkmark \therefore x = 176 \text{ g} \checkmark$$

Option 6

	SO_2	O_2	SO_3
Molar ratio	2	1	2
Initial concentration ($mol \cdot dm^{-3}$)	$\frac{4}{2} = 2$ ✓	y	0
Change in concentration ($mol \cdot dm^{-3}$)	~~1,5~~	~~0,75~~	1,5
Equilibrium concentration ($mol \cdot dm^{-3}$)	~~0,5~~	~~y – 0,75~~ ✓	1,5

Ratio ✓

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]} \checkmark \therefore 4,5 = \frac{(1,5)^2}{(0,5)^2(y - 0,75)} \checkmark \therefore y = 2,75 \text{ mol} \cdot \text{dm}^{-3}$$

$m = cMV = (2,75)\checkmark(32)\checkmark(2) \checkmark = 176 \text{ g} \checkmark$

[12.1.3] (9)
[28]

QUESTION 8

8.1 Salt bridge ✓ [12.2.1] (1)

8.2 Concentration of the electrolyte – 1 $mol \cdot dm^{-3}$ ✓
Temperature – 25 °C/298 K ✓ [12.2.1] (2)

8.3 Pb^{2+} ✓/ lead(II) ions / lead ions [12.2.3] (1)

8.4 $E^o_{cell} = E^o_{cathode} - E^o_{anode}$ ✓ OR any other correct formula from data sheet
1,53 ✓= (-0,13) ✓- E^o_{anode}
E^o_{anode} = -1,66 (V) ✓

∴ unknown metal X is Aℓ ✓

[12.2.3] (5)

8.5 $2A\ell + 3Pb^{2+} \rightarrow 2A\ell^{3+} + 3Pb$

(reactants ✓ ; products ✓; bal ✓) [12.2.3] (3)

8.6 Decreases ✓✓ [12.2.2] (2)

8.7 0 V✓✓ [12.2.2] (2)
[16]

QUESTION 9

9.1 P ✓ [12.2.3] (1)

9.2 9.2.1 Ag / Silver ✓ [12.2.1] (1)

9.2.2 Silver nitrate / $AgNO_3$ ✓ or silver ethanoate /acetate / CH_3COOAg.
(These are the only two soluble silver salts.) [12.2.1] (1)

9.3 9.3.1 Silver /metal bar becomes eroded /pitted/ smaller / thinner / eaten away ✓ [12.1.1] (1)

9.3.2 A (silver) layer forms on the medal. ✓ [12.1.1] (1)

9.4 $Ag^+ + e^- \rightarrow Ag$ ✓✓ [12.2.3] (2)

9.5 Remains the same. ✓ [12.2.3] (1)

9.6 Replace the silver solution with a copper solution✓/soluble copper salt.

Replace the silver bar/electrode P/anode with a copper bar.✓ [12.2.3] (2)
[10]

QUESTION 10

10.1 +2 ✓ [12.2.3] (1)

10.2 $Pb + PbO_2 + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$

OR

$Pb + PbO_2 + 2H^+ + 2HSO_4^- \rightarrow 2PbSO_4 + 2H_2O$

(reactants ✓ ; products ✓ bal ✓) [12.2.3] (3)

10.3 Pb / lead✓
Pb is oxidised/loses electrons. /Highest reducing ability / stronger reducing agent / smaller reduction potential (E^o)✓/causes reduction /
The oxidation number of Pb increases (from 0 → 2) [12.2.3] (2)

10.4 $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ ✓✓ [12.2.3] (2)

10.5 The gases produced during recharging (hydrogen and oxygen) may explode if sparked. ✓ [12.3.2] (1)

10.6 Charge = (3,5)(1)(60)(60) ✓ ✓ [12.1.3]
= 12 600 C✓

Number of electrons = $\frac{q}{1,6 \times 10^{-19}}$

= $\frac{12\,600}{1,6 \times 10^{-19}}$ ✓

= 7,88 x 10^{22} electrons✓ (5)

[14]

TOTAL SECTION B: 125
GRAND TOTAL: 150