



NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2015

PHYSICAL SCIENCES: PAPER II

MARKING GUIDELINES

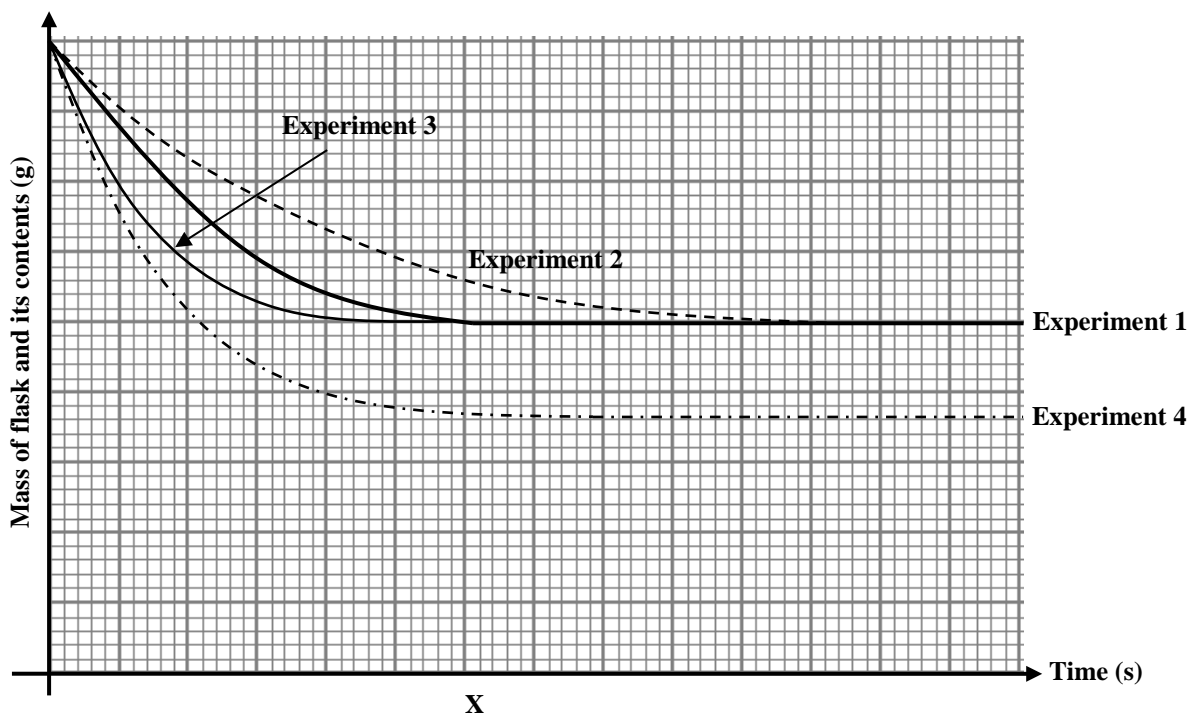
Time: 3 hours

200 marks

These marking guidelines are prepared for use by examiners and sub-examiners, all of whom are required to attend a standardisation meeting to ensure that the guidelines are consistently interpreted and applied in the marking of candidates' scripts.

The IEB will not enter into any discussions or correspondence about any marking guidelines. It is acknowledged that there may be different views about some matters of emphasis or detail in the guidelines. It is also recognised that, without the benefit of attendance at a standardisation meeting, there may be different interpretations of the application of the marking guidelines.

3.2 Graph to show the relationship between the mass of the flask and its contents, and time for the reaction of $\text{CaCO}_3(\text{s})$ with $\text{HCl}(\text{aq})$.



Allocation of marks

- One mark in each case for correct gradient.
- Experiment 2: Correct final mass (and graph levels out after time X.)
- Experiment 3: Correct final mass (and graph levels out before time X.)
- Experiment 4: Final mass less than that shown for Experiment 1. (6)

3.3 No (do NOT agree with Siya).

The reason why the graph levels out is because the **hydrochloric acid (or limiting reagent) is used up**

OR the reaction has gone to completion.

OR the **reaction stops**.

This reaction cannot reach dynamic chemical equilibrium since it is **not taking place in a closed system**.

OR It cannot reach equilibrium as **one of the products is leaving the flask**.

OR It cannot reach equilibrium because the reaction is not reversible. (3)

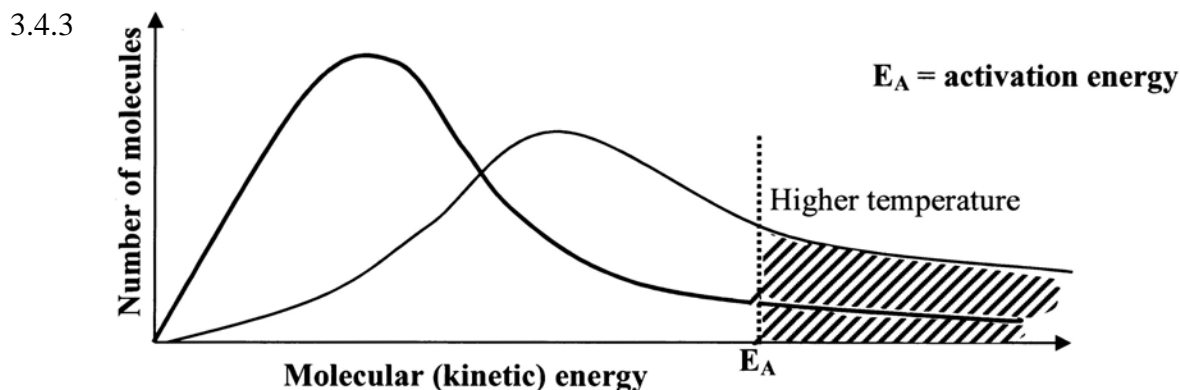
(No mark is to be awarded for saying 'No'. The marks are for the justification.)

3.4 3.4.1 Activation energy is the **minimum** energy required to start a chemical reaction. (2)

3.4.2 The **fraction (number) of molecules (particles)** with ... energy equal to or greater than the activation energy.

OR ... enough energy to form products.

OR ... to collide successfully/react. (2)

**Mark allocation:**

- One mark for peak of graph being lower than original graph.
- One mark for 'shift of graph to right' with end of graph being higher than original. (2)

- 3.4.4 More of the molecules will have kinetic energy (equal to or) greater than the activation energy (as shown by larger shaded area under graph). This will lead to **more effective collisions** per second which leads to a **faster reaction rate**. (3)
- [20]**

QUESTION 4 CHEMICAL EQUILIBRIUM

- 4.1 4.1.1 Le Chatelier's principle states: When an external stress is applied to a system in chemical equilibrium, the equilibrium point will change in such a way as to counteract the stress. (3)
- 4.1.2 Dynamic equilibrium is reached in a chemical reaction in which the forward and reverse reactions (continue to) take place (simultaneously) at the same rate. (2)
- OR** Rate of forward reaction = rate of reverse reaction (2)
- OR** Dynamic chemical equilibrium is reached when the concentration of the reactants and products remains constant **OR** is in a constant ratio.
- 4.1.3 (a) Increase. (1)
- (b) Decrease. (1)
- 4.1.4 Stress: Increase pressure
Response: Favour reverse reaction (Equilibrium shifts to the left)
Reason: The reverse reaction produces fewer moles of gas, which relieves the stress of high pressure. (3)
- 4.2 4.2.1 No as the system is not in a state of (dynamic chemical) equilibrium. (2)
- 4.2.2 $O_2(g)$ was removed from the reaction vessel or $[O_2]$ decreased.
The **reverse reaction was favoured**. The concentration of the products, NO and H_2O , decreased as they reacted to produce O_2 and relieve the stress. This led to an increase in the concentration of the reactants. (4)

- 4.2.3 (a) Exothermic. (1)
- (b) Stress: Decrease temperature
 Response: Favour forward (or exothermic) reaction as shown by decrease in [reactants] and increase in [products]
 Reason: Forward reaction produces heat (\therefore exothermic), which relieves stress of low temperature. (4)
- [21]

QUESTION 5 ACIDS AND BASES

- 5.1 5.1.1 HCl (1)
 5.1.2 NaOH (1)
 5.1.3 CH₃COOH (1)
 5.1.4 H₃PO₄ (1)
 5.1.5 Li₂SO₄ (1)
 5.1.6 K₂SO₃ (1)
- 5.2 $\text{NH}_4\text{NO}_3(\text{s}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{NO}_3^-(\text{aq})$
 $\text{H}_2\text{O}(\ell) \rightleftharpoons \text{OH}^-(\text{aq}) + \text{H}^+(\text{aq})$

Consider the pairs of ions formed:

- NH₄⁺ and OH⁻ ions would form a **weak base (NH₄OH)** which is **not completely dissociated**.
- H⁺ and NO₃⁻ ions would form a **strong acid (HNO₃)** which remains **completely ionised**.
- Thus, **OH⁻ ions are removed from solution**, upsetting the equilibrium of water (favouring the forward reaction) and leaving an **excess of H⁺ (or H₃O⁺) ions**, hence a weakly acidic solution. (4)

OR

The NH₄⁺ ion (strong conjugate acid of weak base NH₄OH) donates a proton to water to form H₃O⁺ OR $\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{NH}_3$
 The NO₃⁻ ion (weak conjugate base of strong acid HNO₃) does not react.
 The equilibrium in water is upset leading to an excess of H₃O⁺ (increase in H₃O⁺).

- 5.3 5.3.1 A strong acid is one that **ionises** (almost) completely (in an aqueous solution). (2)
- 5.3.2 **HI** It has a higher K_a, which indicates that it ionises more than HF does OR it indicates that it has a higher concentration of H₃O⁺ ions. (3)
- 5.3.3 **HI** since it would have a higher concentration of (free) ions (as it ionises more). (2)
- 5.3.4 (a) Decrease. (1)
 (b) Increase (Answer must be consistent with Question 5.3.4 (a)) (1)
 (c) Increase (Answer must be consistent with Question 5.3.4 (a)) (1)

5.3.5 (a) $K_w = [H_3O^+].[OH^-] = 1 \times 10^{-14}$
 $[OH^-] = \frac{1 \times 10^{-14}}{0,02}$
 $[OH^-] = 5 \times 10^{-13} \text{ mol}\cdot\text{dm}^{-3}$ (3)

(b) $K_a = \frac{[H_3O^+].[F^-]}{[HF]}$ Round brackets (-) (2)

(c) $6,6 \times 10^{-4} = \frac{0,02 \times 0,02}{[HF]}$
 $[HF] = 0,61 \text{ mol}\cdot\text{dm}^{-3}$ (3)

5.4 5.4.1 $n = c.V$
 $n = 0,15 \times 0,6$ (conversion to dm^3)
 $n = 0,09 \text{ mol of } H_2SO_4$ (3)

5.4.2 $n = \frac{m}{M}$ OR $m = (80\% \text{ of } 11,2) = 8,96 \text{ g}$
 $n = \frac{11,2}{56} \times \frac{80}{100}$ $n = \frac{8,96}{56}$
 $n = 0,16 \text{ mol of KOH}$ $n = 0,16 \text{ mol of KOH}$ (4)

5.4.3 **Acidic**

Mol ratio $H_2SO_4 : KOH$
 $1 : 2$
 $0,08 : 0,16$

OR $0,09 : 0,18$ (not enough)

\therefore There will be an **excess of H_2SO_4** (0,01 mol of H_2SO_4 in excess) (3)
[38]

QUESTION 6 GALVANIC CELL

6.1 **Chemical** (potential) energy to **electrical** energy. (2)

6.2 $\text{Al}|\text{Al}^{3+}||\text{Ni}^{2+}|\text{Ni}$ Anode; Salt bridge; Cathode If include 'balancing co-efficients' (2Al & 3Ni) -1 (3)

6.3 6.3.1 Oxidation is loss of electrons. (1)

6.3.2 Oxidising agent is an electron acceptor. (1)

6.4 Ni^{2+} (1)

6.5 $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$
 $= -0,25 - (-1,66)$
 $E^\circ_{\text{cell}} = \mathbf{1,41\ V}$ (2)

6.6 6.6.1 Decreases (1)

6.6.2 Decreases (to zero) (1)

6.7 6.7.1 No effect (1)

6.7.2 Decreases (1)

6.7.3 Increases (1)

6.8 6.8.1 $n = \frac{m}{M}$
 $= \frac{1,77}{59}$
 $= \mathbf{0,03\ mol}$ (2)

6.8.2 Mol ratio $\text{Al} : \text{Ni}$
 $2 : 3$
 $0,02 : 0,03$
 Mass of Al $= n \times M$
 $= 0,02 \times 27$
 $= \mathbf{0,54\ g}$ (3)

[20]

QUESTION 7 ELECTROLYSIS

7.1 7.1.1 copper(II)chloride (CuCl_2) (1)

7.1.2 water (H_2O) (1)

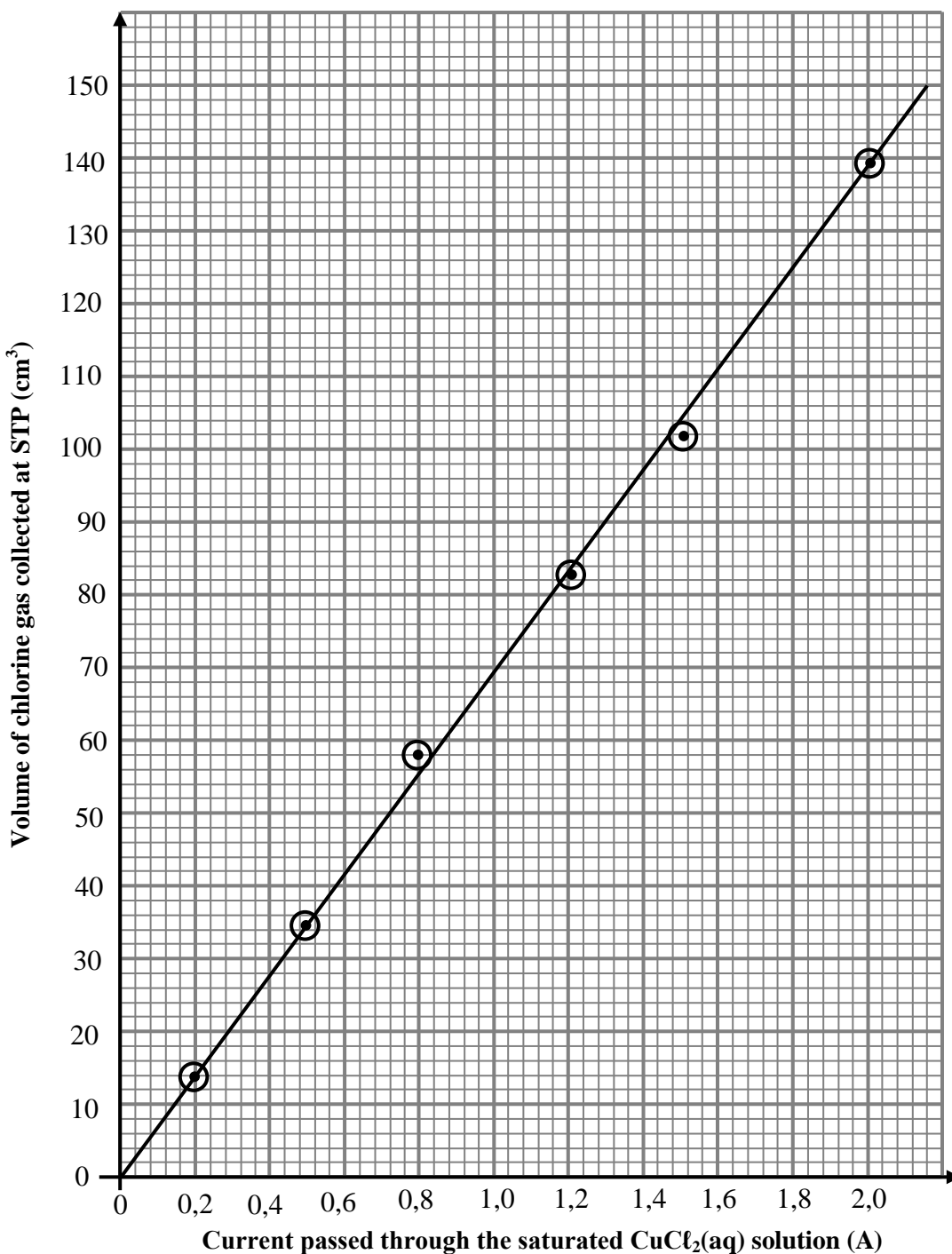
7.1.3 ion-dipole forces (Van der Waal's forces only = one mark only) (2)

7.1.4 (a) $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$ (2)

-1 per error
-1 in total if double arrows shown

(b) $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$ (2)

7.1.5 **Graph to show the relationship between current passed through the saturated $\text{CuCl}_2(\text{aq})$ solution and the volume of chlorine gas collected at STP.**



Marking of graph:

- | | | |
|---|--|-----|
| • Heading | <u>Scale</u> | |
| • Labels on both axes with units | Must use at least half of blocks on each axis. | |
| • Scales on both axes | If scale completely wrong then no marks awarded for plotting points. | |
| • Points | | |
| • Best fit straight line through origin | <u>Swop axes</u> (-2) | (7) |

7.1.6 The volume of chlorine gas produced is **directly proportional** to the current. (2)

OR

As current increases the volume of gas produced increases. (1 mark only)

It is **WRONG** to say current is directly proportional to the volume of chlorine gas produced.

7.1.7 Gradient = $\frac{\Delta \text{ volume}}{\Delta \text{ current}} = \frac{V_f - V_i}{I_f - I_i}$
 $= \frac{139,3 \text{ cm}^3}{2,0 \text{ A}}$ Other points may be used
 $= \mathbf{69,65 \text{ cm}^3 \cdot \text{A}^{-1}}$ (Allow 67 – 71) (3)

7.1.8 $V = 25 \times 69,65$ (c.o.e from 7.1.7)
 $= \mathbf{1\ 741,25 \text{ cm}^3}$ (2)

7.1.9 (a) $n = \frac{V}{V_m}$
 $= \frac{0,1393}{22,4}$ (mark for conversion to dm^3)
 $= 0,0062 \text{ mol (of Cl}_2\text{)}$ (2)

(b) Mol Ratio $\text{Cl}_2 : e^-$
 $1 : 2$
 $0,0062 : 0,0124$

OR

$Q = n \cdot F$
 $= 0,0124 \times 96\ 500$
 $= 1\ 196,6 \text{ C}$

no. of $e^- = 0,0124 \times 6,02 \times 10^{23}$
 $= 7,46 \times 10^{21} e^-$

$t = \frac{Q}{I}$
 $\frac{1\ 196,6}{2}$
 $t = \mathbf{598,3 \text{ s}}$

$Q = Ne \times qe$
 $= 7,46 \times 10^{21} \times 1,6 \times 10^{-19}$
 $Q = 1\ 194,4 \text{ C}$

$t = \frac{Q}{I}$ $t = \frac{1\ 194,4}{2}$
 $t = 597,20$ (5)

7.2 7.2.1 $2\text{H}_2\text{O} + 2e^- \rightarrow \text{H}_2 + 2\text{OH}^-$ (-1 per error) (2)

7.2.2 Na^+ ions are a **weaker oxidising agent** than H_2O molecules .

OR Na^+ ions have a **lower reduction potential** than H_2O .

$\therefore \text{Na}^+$ ions are **not reduced to form Na** (2)

7.2.3 H_2 and Cl_2 react explosively \therefore dangerous and destroys product.

Chlorine reacts with sodium hydroxide to produce sodium hypochlorite (bleach). ($\text{NaOH} + \text{Cl}_2 \rightarrow \text{NaOCl} + \text{HCl}$)

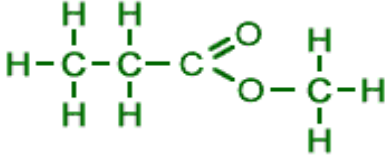
(ONE reason only) (2)

[35]

QUESTION 8 ORGANIC CHEMISTRY

8.1 A homologous series is a series of compounds which have the **same functional group** and have the **same general formula**, in which each member differs from the other by a single CH₂ unit. (3)

8.2 Alkanes (1)

8.3 

- Ester linkage correct (with 3:1 ratio)
- Propyl and methyl correct way around
- -1 if all H's missing

(2)

8.4 Methanol and propanoic acid (2)

8.5 hydroxyl or –OH (NOT hydroxide or OH⁻) (1)

8.6 X (1)

8.7 8.7.1 CH₃CH₂CH₂CH₂CH₂OH → CH₃CH₂CH₂CH=CH₂ + H₂O (3)

8.7.2 pent -1-ene OR 1-pentene (pentene = 1 mark only) (2)

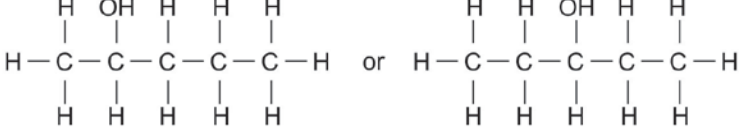
8.7.3 elimination (1)

8.8 2C₆H₁₄ + 19O₂ → 12CO₂ + 14H₂O Products O₂ balanced (4)

8.9 8.9.1 Isomers are compounds having the same molecular formula but different structural formulae. (2)

8.9.2 Hexane (2)

8.9.3 butanoic acid OR 2-methylpropanoic acid carboxylic acid 4 C (2)

8.9.4 

5 Cs with all Hs correct – OH correct (2)

8.10 **X** (2,3-dimethylbutane) has **induced/temporary/momentary dipole forces or London forces or dispersion forces** between its molecules.
Y (methyl propanoate) has **dipole-dipole forces** between its molecules.
Z (pentan-1-ol) has **hydrogen bonds** between its molecules.
London forces are the weakest type of intermolecular force.
Hydrogen bonds are the strongest type of intermolecular force.
More energy is needed to break the stronger intermolecular forces, therefore boiling point is lowest for X (2,3-dimethylbutane) and highest for Z (pentan-1-ol). (6)

[34]

Total: 200 marks