NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2023

# PHYSICAL SCIENCES: PAPER II

## MARKING GUIDELINES

Time: 3 hours | 200 marks

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**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.**

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## QUESTION 1 MULTIPLE-CHOICE QUESTIONS

1.1 D
1.2 A
1.3 C
1.4 C
1.5 C
1.6 D
1.7 A
1.8 B
1.9 B
1.10 D

## QUESTION 2

2.1 A measure of the tendency of an atom to attract a bonding pair of electrons (in context)

2.2 A sharing of at least one pair of electrons by two non-metal atoms
OR A bond occurring between atoms within molecules

2.3 S and O Non-metal atoms
with different electronegativity. OR with unequal sharing of electrons
*(If two non-metals stated in 2.2 above, do not penalise if omitted in 2.3)*

2.4
2.4.1 a homogeneous mixture of solute and solvent
2.4.2 water OR $H_2O$
2.4.3 ionic bonds / electrostatic forces / Coulombic forces
2.4.4 A substance that can conduct electricity by forming free ions when molten or dissolved in solution.
2.4.5 Yes

## QUESTION 3

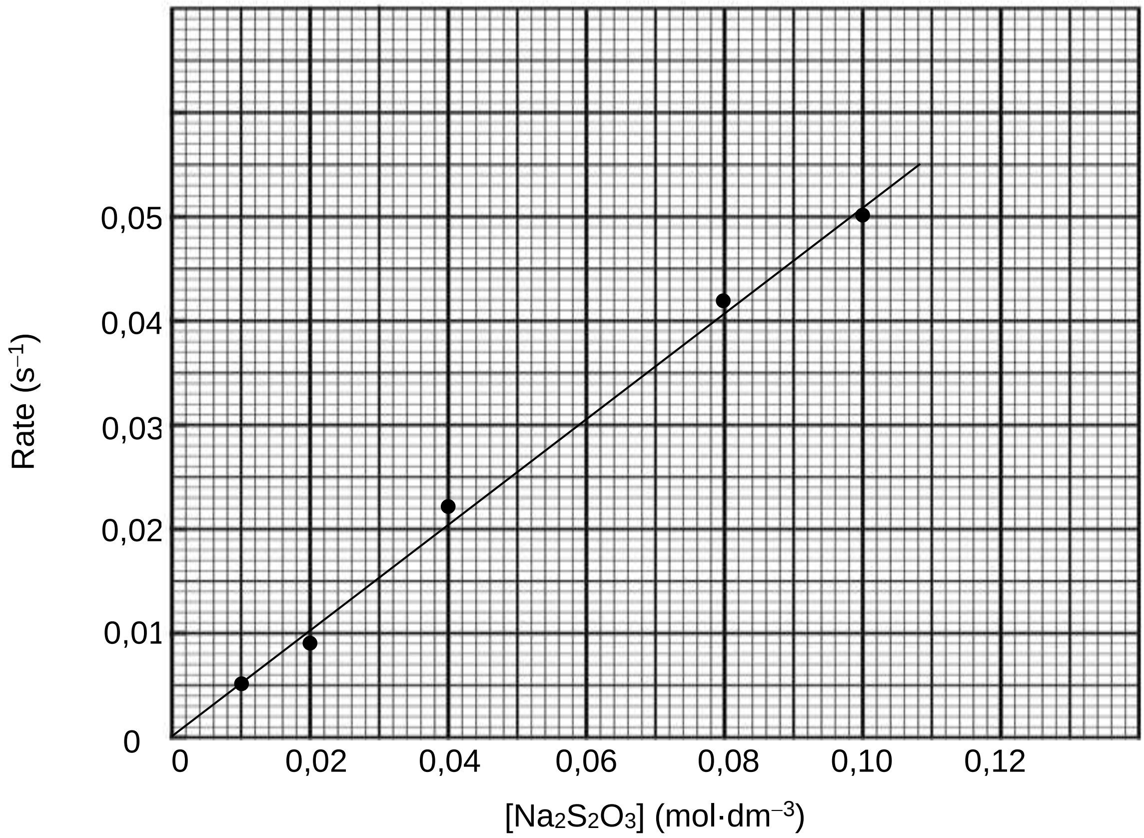
3.1 the change in amount (moles) or concentration per unit time of either a reactant or a product. (not 'over time')

3.2
3.2.1 $n(Na_2S_2O_3) = cV = 0{,}1 \times 0{,}025 = 0{,}0025$ mol ($2{,}5 \times 10^{-3}$ mol)
$n(HC\ell) = cV = 0{,}15 \times 0{,}005 = 0{,}00075$ mol ($7{,}5 \times 10^{-4}$ mol)
0,0025 mol $Na_2S_2O_3$ needs 0,005 mol $HC\ell$
OR: 0,00075 mol $HC\ell$ reacts with 0,000375 mol $Na_2S_2O_3$
$\therefore$ $HC\ell$ is limiting reagent (and $Na_2S_2O_3$ is in excess)

3.2.2 *(must use $HC\ell$: given as LR)*
0,00075 mol $HC\ell$ (coe) produces $3{,}75 \times 10^{-4}$ mol S (2:1)
$N(S) = nN_A = 3{,}75 \times 10^{-4} \times 6{,}02 \times 10^{23}$ (or implied formula)
$= 2{,}26 \times 10^{20}$ S atoms
If *$n(Na_2S_2O_3)$* used max 1/3 for equation.

3.3

Graph of the rate vs the concentration of $Na_2S_2O_3$




y-axis scale plotting of points best fit straight line through zero

3.4 Read off rate at 0,03 $mol \cdot dm^{-3}$ from LOBF ≈ 0,015 $s^{-1}$.
Time = 1 / 0,015 = 66,67 s

3.5 The rate of the reaction is **directly proportional** to the concentration of the sodium thiosulfate.
OR
As concentration increases, rate increases by the same factor

3.6 3.6.1 When rate increases from 0,02 $s^{-1}$ to 0,04 $s^{-1}$
Temperature increases by 52 – 38 = 14 °C
OR from 0,03 $s^{-1}$ to 0,06 $s^{-1}$ = 60 – 46 = 14 °C
OR Use any other two points where rate doubles.

3.6.2 When the temperature is increased, the particles have more $E_k$ / are moving faster ∴ more particles will have $E_k \geq E_a$ (must specify $E_k$ or kinetic energy). There will be more collisions per unit time. Both factors increase the number of effective collisions per unit time ∴ rate increases exponentially.

## QUESTION 4

4.1 equilibrium constants are temperature dependent

4.2 $K_c = \frac{[A_3B_2]}{[B]^2}$ top bottom *–1 if no square brackets*

4.3 4.3.1

| | $3A(s) + 2B(g) \rightleftharpoons$ | $A_3B_2(g)$ | |
|---|---|---|---|
| Initial mol | **0,3** | **0** | |
| Change mol | –2x | + x | |
| Equil mol | 0,3 – 2x | x | |
| Conc | $\frac{0,3 - 2x}{2}$ | $\frac{x}{2}$ | *divide by 2* |

$(K_c =) \frac{(\frac{x}{2})}{(\frac{0,3-2x}{2})^2} = 1,65$ *substitute (coe)*

OR

| | $3A(s) + 2B(g) \rightleftharpoons$ | $A_3B_2(g)$ | |
|---|---|---|---|
| [Initial] | **0,15** | **0** | *divide by 2* |
| [Change] | –x | + x / 2 | |
| [Equil] | 0,15 – x | **x / 2** | |

$(K_c =) \frac{(\frac{x}{2})}{(0,15 - x)^2} = 1,65$ *substitute (coe*

4.3.2 (a) 0,3 – 2(0,56) < 0

OR: There is not enough B to produce this amount of $A_3B_2$

Ratio is 2:1 or would need 1,12 mol B

OR: 0,3 / 2 = 0,15 mol is the maximum amount of $A_3B_2$ possible

OR: 0,56 mol > 0,3 mol. Ratio is 2:1

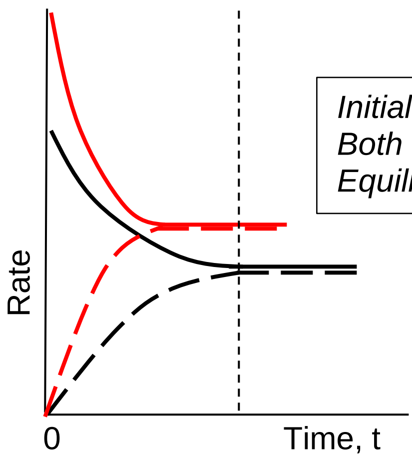
(b) $(0,3 – 2(0,04)) / 2 = 0,11\ mol{\cdot}dm^{-3}$

OR $0,15 – 0,04 = 0,11$ m $mol{\cdot}dm^{-3}$

4.4 4.4.1 (a) remain the same

(b) remain the same

4.4.2




*Initial rate of forward reaction is higher.*
*Both rates higher at equilibrium.*
*Equilibrium is reached sooner.*

4.5 4.5.1 increase

4.5.2 The exothermic forward reaction will be favoured to increase the temperature / release thermal energy / produce heat / relieve the stress (*linked to stress identified as temperature decrease*)

4.5.3 increase *(coe from 4.5.1)*

## QUESTION 5

5.1 **tri**protic

5.2 5.2.1 $K_a = 7{,}1 \times 10^{-4}$

5.2.2 (a) BASE
(b) $H_2A^- + H_2O \rightleftharpoons HA^{2-} + H_3O^+$
OR: $H_2A^- + H_2O \rightleftharpoons A^{3-} + H_3O^+ + 2H_3O^+$

5.3 5.3.1 The splitting of an ionic compound into its ions

5.3.2 $Na_3A \rightarrow 3Na^+ + A^{3-}$

5.3.3 basic

5.4 $m = cVM = 3{,}81 \times 10^{-2} \times 0{,}2 \times 192 = 1{,}46$ g
*Equation volume conversion substitution answer*
**OR** $n = cV = 3{,}81 \times 10^{-2} \times 0{,}2 = 7{,}62 \times 10^{-3}$ mol
$m = nM = 7{,}62 \times 10^{-3} \times 192 = 1{,}46$ g
*both equations substitutions volume conversion answer*

5.5 Each (aliquot) amount transferred into conical flask / titrated must have the same concentration, so that the results are correct / precise / accurate / reliable / valid
OR: If the concentration must be uniform (solute and solvent must be mixed completely) OR the concentration must be correct so that the titration readings are precise (small range in end-point volumes) OR to get an accurate result

5.6 5.6.1 phenolphthalein
5.6.2 pink to colourless *(coe from 5.6.1)*

5.7 $n(H_3A) = cV = 3{,}81 \times 10^{-2} \times 0{,}0326 = 1{,}242 \times 10^{-3}$ mol
$n(NaOH) = 1{,}242 \times 10^{-3} \times 3 = 3{,}726 \times 10^{-3}$ mol
$c(NaOH) = n / V = 3{,}726 \times 10^{-3} / 0{,}0250 = 0{,}149$ mol·dm$^{-3}$
*Volume conversion not penalised if it cancels*

OR USE: $\dfrac{c_aV_a}{c_bV_b} = \dfrac{n_a}{n_b}$ *or other version thereof*

$\dfrac{3{,}81 \times 10^{-2} \times 32{,}6}{c_b \times 25} = \dfrac{1}{3}$ *ratio indicated*

$c(NaOH) = 0{,}149$ mol·dm$^{-3}$

*–1 if not 3dp. Accept $1{,}49 \times 10^{-1}$*

5.8 Less than He removed some of the dissolved solute ($H_3A$) OR he added too much water

5.9 5.9.1 higher (coe)

5.9.2 His titration volume ($V_a$) will be higher (he will need to use more $H_3A$ to neutralise the NaOH)

## QUESTION 6

6.1 $Fe(s) | Fe^{3+}(aq) || C\ell_2(g) | C\ell^-(aq)$ | **Pt(s) OR** | **C(s)** *(–1 for any omissions)*

6.2 the electrode where oxidation takes place

6.3 Fe or iron

6.4 $2Fe + 3C\ell_2 \rightarrow 2Fe^{3+} + 6C\ell^-$ *reactants products balanced*
*Double arrow –1*

6.5 6.5.1 A solution of known concentration

6.5.2 $Fe(NO_3)_3 = 1\ mol\cdot dm^{-3}$
$CaC\ell_2 = 0,5\ mol\cdot dm^{-3}$
*–1 in total if units incorrect*

6.6 The pressure of the (chlorine) gas must be $1,01 \times 10^5$ Pa

6.7 $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$
$= 1,36 - (-0,04)$
$= 1,40$ V

6.8 Voltage of cell increases
Chloride concentration decreases
Forward cell reaction favoured
To make more chloride / counteract the stress

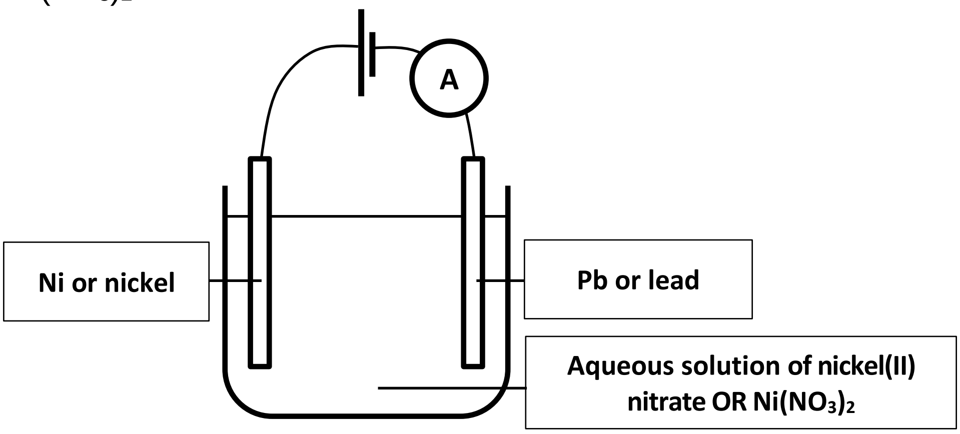
## QUESTION 7

7.1 7.1.1 (a) $Cu^{2+}$
(b) Cu
(c) remain constant

7.1.2 (a) C
(b) it has free / delocalised electrons (that can move / are mobile)
(c) (i) $Cu^{2+}$
(ii) $H_2O$
(iii) decrease

7.2 7.2.1 $Pb(NO_3)_2$

7.2.2




7.2.3 (a) Lead rod is plated with nickel (M = 59).
$n(Ni) = m / M = 1,10 / 59 = 0,0186$ mol
$n(e^-) = 0,0186 \times 2 = 0,0373$ mol

(b) EITHER: $q = nF = 0,0373$(coe) $\times 96500 = 3599,45$ C
$I = q / t = 3599,45 / (30 \times 60) = 2$ A *(both formulas)*

OR: $N(e^-) = nN_A = 0,0373$(coe) $\times 6,02 \times 10^{23} = 2,25 \times 10^{22}$
$q = N \times 1,6 \times 10^{-19} = 3592,74$ C *(both calcs)*
$I = q / t = 3592,74 / (30 \times 60) = 2$ A *(all formulas)*

7.2.4 $H_2O$ is a stronger oxidising agent than $A\ell^{3+}$
$H_2O$ will be reduced at the cathode, not $A\ell^{3+}$

## QUESTION 8

8.1 8.1.1 substitution

8.1.2 Contains C and H only
All C−C bonds are single bonds

8.1.3 (a) $n(C_5H_{12}) = m / M = 45 / 72 = 0{,}625$ mol
$n(C\ell_2) = 2 \times 0{,}625 = 1{,}25$ mol
$V(C\ell_2) = nV_m = 1{,}25 \times 22{,}4 = 28\ dm^3$
- *Divide mass by 72*
- *Apply mole ratio*
- *Use $V = nV_m$ OR $n = V / V_m$*
- *Subsitute n and 22,4 to solve for answer*
- *Answer*

(b) $n(C_5H_{10}C\ell_2) = 0{,}625$ mol
$m(C_5H_{10}C\ell_2) = nM = 0{,}625 \times 141 = 88{,}13$ g (theoretical)
actual mass = 76% of 88,13 = 66,98 g *(w/o rounding)*
OR: 76% of 0,625 = 0,475 mol
M = nM = 0,475 mol × 141 = 66,98 g

8.1.4 1,3–dichloro –2–methyl butane
*(–1 in total for incorrect punctuation: comma or dash, not one word)*

8.1.5 $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ *balanced*

8.1.6 (a) Compounds having the same molecular formula but different structural formulae
(b) $CH_3C(CH_3)_2CH_3$

8.2 8.2.1 an atom or group of atoms that form the centre of chemical activity in the molecule
8.2.2 C=C
8.2.3 $CH_3CHCHCH_2CH_3$ OR $CH_3$-CH=CH-$CH_2$-$CH_3$
8.2.4 False
8.2.5 pent-1-ene

## QUESTION 9

9.1 hydroxyl

9.2 Ethanol has (London forces and) hydrogen bonding IMFs
$CO_2$ has London / dispersion / induced dipole IMFs
Hydrogen bonds are stronger than London forces
More energy is required to overcome them OR a higher temperature is needed to change the phase
*NOT ethanol has dipole-dipole forces and hydrogen bonds*

9.3 9.3.1 water / $H_2O$ / steam
9.3.2 chloroethane
9.3.3 (a) hydration
(b) hydrolysis

9.4 9.4.1 ester
9.4.2 hexanoic acid
9.4.3 $H_2O$ / water
9.4.4 (concentrated) $H_2SO_4$ / sulfuric acid / phosphoric acid
9.4.5 octanoic acid
*Must be carboxylic acid with 8 Cs*

**Total: 200 marks**