NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 2025

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.

QUESTION 1 MULTIPLE CHOICE

1.1 B

1.2 A

1.3 D

1.4 C

1.5 A

1.6 B

1.7 D

1.8 C

1.9 C

1.10 D **[20]**

QUESTION 2

2.1 2.1.1 (a) polar covalent bond

(b) Hydrogen bond

2.1.2 (a) pure (non-polar) covalent bond

(b) London / induced dipole / dispersion force

2.1.3 ionic bond

2.1.4 metallic bond

2.1.5 dipole-dipole force

2.2 2.2.1 TEMPORARILY

2.2.2 PERMANENTLY

2.3 Iron or Fe; electrons can move

2.4 2.4.1 London forces (in I_2)

2.4.2
- Iodine has a bigger electron cloud and larger (temporary) dipoles.
- London forces in I_2 are stronger than hydrogen bonds in methanol.
- More energy is required to overcome the forces between iodine molecules.

I_2 more electrons *Larger δ^+/δ^-* *London forces in I_2 stronger than H-bond in methanol* *Or IMF in I_2 stronger than IMF in methanol (as H-bond and London examined already)* *More energy*

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QUESTION 3

3.1 The net change of chemical potential energy of the system.

3.2 The products have less potential energy than the reactants.

OR

More energy is released when product bonds form than required to break reactant bonds.

3.3 The cotton wool allows (CO_2) gas to escape but prevents any liquid from escaping.

Gas escapes; only gas / nothing else / no liquid

3.4 3.4.1 $n(CaCO_3) = m/M$
$= 1{,}5 / 100$
$= 0{,}015$ mol
$n(H_3PO_4) = cV$
$= 2 \times 0{,}02$
$= 0{,}04$ mol

EITHER 0,015 mol $CaCO_3$ reacts with 0,01 mol H_3PO_4 (3:2) (< 0,04 mol)

OR

0,04 mol H_3PO_4 reacts with 0,06 mol $CaCO_3$ (2:3) (> 0,015 mol)

$\therefore$ H_3PO_4 is in excess

- *Formulas*
- *molar mass of $CaCO_3$*
- *volume conversion*
- *ratio applied correctly*

3.4.2 $n(CO_2) = n(CaCO_3)$
$= 0{,}015$ mol (coe from 3.4.1)
OR $n(CO_2) = n(H_3PO_4 \text{ used})/2 \times 3$
$= 0{,}01 / 2 \times 3$
$= 0{,}015$ mol
$m = nM$
$= 0{,}015 \times 44$
$= 0{,}66$ g *(max 2/3 if answer is obviously not X on the graph)*

- *Correct ratio **applied** (c.o.e)*
- *molar mass of CO_2*
- *Answer with unit*

3.5 Rate = gradient = $\Delta y / \Delta x$
$= (0{,}66 \text{ coe} - 0{,}45) / (12 - 6)$
$= 0{,}035\ g{\cdot}min^{-1}$
(*Accept reading of 0,44 - 0,46 g and answer of 0,033 – 0,037 $g{\cdot}min^{-1}$*)

- *Read off 0,44 – 0,46 value at 6 min*
- *Substitution into gradient formula*
- *Answer with 3 dp and unit*

3.6

Stage	Time interval (min)	The reaction rate (increases / decreases / remains constant / is zero)	Predominant factor affecting the rate
I	0 – 4	Increases	Temperature increases (exothermic)
II	6 – 12	Decreases	Reactants are **used up**. [H_3PO_4] and amount/surface area of $CaCO_3$ decrease.
III	12 – 20	Is zero	Limiting reagent ($CaCO_3$) is **used up**

3.7 3.7.1 Q

3.7.2 P

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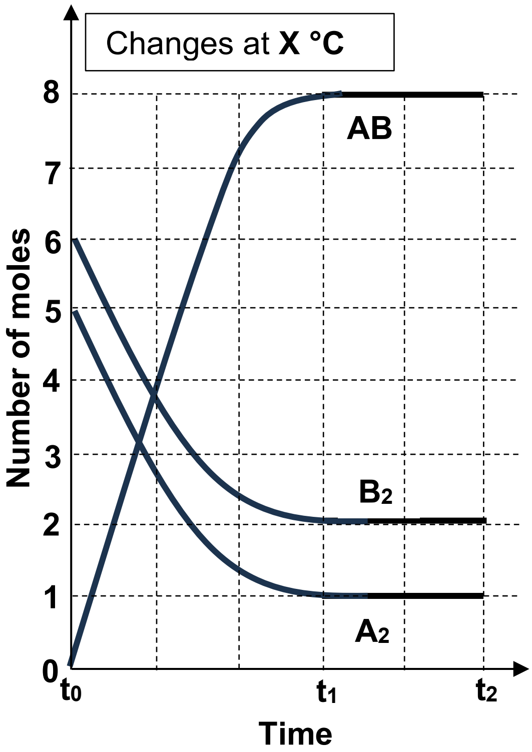
QUESTION 4

4.1



- *Initially: 5 mol A_2, 6 mol B_2, 0 mol AB*
- *Final A_2 = 1 mol*
- *Final B_2 = 2 mol*
- *Final AB = 8 mol*
- *Horizontal line t_1 to t_2*

-1 if transitions are not drawn correctly

4.2 4.2.1 $K_c = \frac{[AB]^2}{[A_2][B_2]}$

4.2.2 X °C: $K_c = (8/4)^2 / ((2/4)(1/4))$
$= 32$
Coe from counting error

- *K_c expression: top bottom*
- *sub into correct eqn*
- *solve*
- *V will cancel -1 if not used*

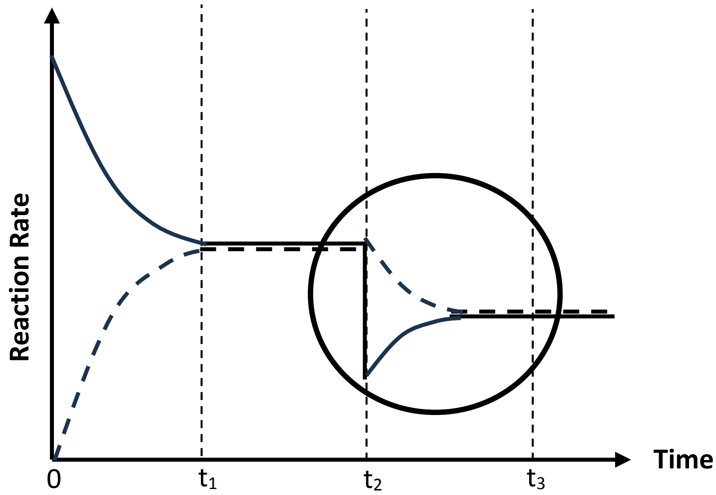
4.2.3 Y °C: $K_c = (2/4)^2 / ((5/4)(4/4))$
$= 0,2$

4.3
- Since the reaction is exothermic,
- a higher temperature would favour the reverse endothermic reaction
- in order to decrease the temperature / oppose the increase in T.
- This would result in a lower K_c value.
- Therefore **Y °C** ((lower K_c) is the higher temperature.)

4.4 4.4.1 There will be more collisions between particles per unit time in the smaller container OR There will be more effective collisions per unit time.
Both forward and reverse reaction rates will increase

4.4.2 Neither reaction will be favoured (OR both rates increase by the same amount) since there are equal moles of gas on each side.
Therefore, the amounts of each substance will remain the same.

4.5



- *Rate of forward reaction decreases at t_2*
- *Rate of reverse reaction decreases thereafter*
- *New rates equal and lower at t_3*

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QUESTION 5

5.1 5.1.1 A proton donor

5.1.2 hydronium (oxonium / hydroxonium)

5.1.3 P or R: less dissolved solute

5.1.4 R: lowest H^+ concentration

5.1.5 P and S: same H^+ concentration

5.1.6 HY: only ionises partially

5.1.7 BASIC
$Y^- + H_2O \rightleftharpoons HY + OH^-$ LHS RHS
Single arrow -1

5.2 5.2.1 It can react with itself in a proton transfer reaction (to form ions).
It can undergo autoionisation *(1)*

5.2.2 It is very low / poor conductor
since the concentration of ions is low.

OR

It increases with temperature
since the number of ions will increase.
The higher the K_W, the higher the conductivity (1)

5.2.3 endothermic

5.2.4 A temperature increase
causes K_W to increase / the forward reaction to be favoured.
OR mention both variables State both increase/decrease

5.2.5 $[H_3O^+] = [OH^-]$

5.2.6 $K_W = [H_3O^+][OH^-] = 4{,}074 \times 10^{-14}$
Since $[H_3O^+] = [OH^-]$
$\therefore 4{,}074 \times 10^{-14} = x^2$
$x = [H_3O^+] = [OH^-]$
$= 2{,}02 \times 10^{-7}$ mol·dm^{-3}

$K_W = [H_3O^+][OH^-]$
Subs of $4{,}074 \times 10^{-14}$ ***and***
recognition that $[H_3O^+] = [OH^-]$
answer

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QUESTION 6

6.1 6.1.1 (A substance that) accepts electrons.

6.1.2 It is easily reduced / it gains electrons relatively easily to form the stable $C\ell^-$ ion.

6.1.3 (a) SO_4^{2-} OR sulfate

(b) (i) $C\ell_2 + 2e^- \rightarrow 2C\ell^-$

(ii) $Fe^{2+} \rightarrow Fe^{3+} + e^-$

(iii) $C\ell_2 + 2Fe^{2+} \rightarrow 2C\ell^- + 2Fe^{3+}$ LHS RHS
Coe from (i) and (ii) but must be balanced for full marks
-1 in total for double arrows

(c) $E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$ *(or alternative)*
$= 1{,}36 - 0{,}77$ *coe from b(iii)*
$= 0{,}59$ V
Positive value $\therefore$ spontaneous

6.1.4 (a) Chlorine is a stronger oxidising agent than manganese(II)
$\therefore$ it will (oxidise manganese to manganese(II)).

(b) Chlorine is a weaker oxidising agent than permanganate
$\therefore$ it will not (oxidise manganese(II) to permanganate).

6.2 6.2.1 Pt / platinum (or graphite)

6.2.2 As a reference electrode to determine the potential of other half-cells.

6.2.3 Pressure of **$H_2(g)$** = 1 atm / 101,3 kPa / $1{,}01 \times 10^5$ Pa
$[H^+]$ / Concentration **of H^+** = 1 $mol{\cdot}dm^{-3}$
Temperature = 25°C

6.2.4 Oxidation (of H_2)
EITHER H_2 is a stronger reducing agent than Cr^{3+}
OR $Cr_2O_7^{2-}$ is a stronger oxidising agent than H^+

6.2.5 H^+ ions are needed (as seen in the $Cr_2O_7^{2-}$ half-reaction)

6.2.6 (a) $K_2Cr_2O_7$
$Cr_2(SO_4)_3$

(b)
- (Since a very concentrated solution can be prepared)
- The solution will be a very good conductor of electricity.
- It will lower the internal resistance of the cell / increase the current the cell can deliver.

(c) → DECREASE (*coe from 6.2.4*)

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QUESTION 7

7.1 electrical to chemicalenergy

7.2 Compartment B

7.3 P chlorine / $C\ell_2$

Q hydrogen / H_2

7.4 $2NaC\ell + 2H_2O \rightarrow 2NaOH + C\ell_2 + H_2$ LHS RHS BAL
-1 if Na^+ spectator ion omitted

7.5
- Under standard conditions,
- H_2O is a stronger reducing agent than $C\ell^-$
- H_2O will be oxidised to O_2 (instead of $C\ell^-$ to $C\ell_2$).
- Using a higher concentration of $C\ell^-$ increases the rate of oxidation of $C\ell^-$ / makes $C\ell^-$ a stronger reducing agent than water.

7.6
- When water is reduced (to H_2),
- OH^- ions are released (at the cathode).
- The Na^+ ions in Compartment **A** pass through the membrane (thus forming NaOH).

7.7 7.7.1 ANODE

7.7.2 The OH^- ions cannot pass through the membrane from the cathode into the anode compartment.

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QUESTION 8

8.1 8.1.1 A combustion (or oxidation)

8.1.2 B esterification (or condensation)

8.2 8.2.1 C halogenation

8.2.2 D dehydrohalogenation

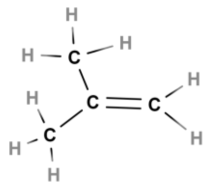
8.2.3 E hydrogenation

8.3 8.3.1 $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$ (*2 or 0*)

8.3.2 (Compounds having the) same **molecular** formula but different structural formulae / structures.

8.3.3 (a) $CH_3CH_2CHCH_2$ / $CH_2CHCH_2CH_3$ (*or semi-structural*)

(b)



-1 per error

8.3.4 methylpropene (*accept 2-methylprop-1-ene*) *-1 if space*

8.4 8.4.1 concentrated H_2SO_4 / sulfuric acid / H_3PO_4

8.4.2 carboxylic acids

8.4.3 methyl butanoate *ester all correct*

8.5 8.5.1 to provide activation energy / break reactant bonds

8.5.2 dibromomethane

8.6 8.6.1 hex-2-ene *(-1 incorrect punctuation)*

8.6.2 (a) hexan-2-ol *(-1 incorrect punctuation)*

(b) hydrolysis

8.7 8.7.1 PRODUCT - has C-C single bonds only / i*s an alkane / has the maximum number of H's attached*

8.7.2 bromine (water)

8.7.3 alkane

8.7.4 hepta-2,4-diene *(-1 incorrect punctuation)*

8.7.5 It has no C / alkyl branches / substituents / side chains
It is a straight-chain compound (1)

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Total: 200 marks

MULTIPLE CHOICE EXPLANATION

1.1	B	SAGS definition
1.2	A	sulfite is SO_3^{2-} ∴ sodium sulfite is Na_2SO_3 ($Na_2S_2O_3$ is sodium thiosulfate)
1.3	D	In Reaction (i), 1 mol NaN_3 produces 1 mol Na and 1,5 mol N_2 In Reaction (ii), the 1 mol Na produces 0,1 × 80% = 0,08 mol N_2 Total N_2 = 1,5 + 0,08 = 1,58 mol
1.4	C	$c(Au(NO_3)_3)$ = n/V = 0,2 / 0,5 = 0,4 $mol \cdot dm^{-3}$ ∴ c(ions) = 0,4 × 4 = 1,6 $mol \cdot dm^{-3}$
1.5	A	S represents the activation energy without a catalyst.
1.6	B	Add Step 1 + Step 2 to get overall reaction: $2N_2O \longrightarrow 2N_2 + O_2$ i.e. decomposition of N_2O ∴ NO is catalyst (used in Step 1 and re-formed in Step 2) and NO_2 is intermediate (created in Step 1, but used up in Step 2).
1.7	D	WA in flask, SB in burette
1.8	C	Au^{3+} is being reduced (reactant) ∴ increasing $[Au^{3+}]$ causes forward reaction to be favoured (to decrease $[Au^{3+}]$) ∴ increasing potential for forward reaction. OR If $[Au^{3+}]$ increases, the value of +1,42 V for gold ($E_{cathode}$) will increase, so E_{cell} will increase. A shorter, wider salt bridge lowers the internal resistance, thus increasing the current.
1.9	C	SAGS definition
1.10	D	Cℓ atoms attach to adjacent C's of the double bond between C3 and C4.