NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 2024

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.

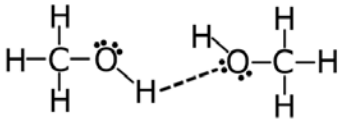
QUESTION 1 MULTIPLE CHOICE

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

QUESTION 2

2.1
- The electron cloud can become unevenly distributed ✓
- resulting in the formation of temporary / instantaneous / momentary dipoles which induce dipoles in neighbouring molecules. ✓
- (The opposite ends of) these dipoles attract each other. ✓

2.2 2.2.1 polar covalent ✓
Pure (non-polar) covalent ✓

2.2.2 

- (Structural) formula of methanol ✓
- H-bond indicated between the H covalently bonded to O ✓
and the (lone pair on) O of neighbouring molecule ✓

Not necessary to show lone pairs

2.2.3 N_2 has London forces. ✓
CO has similar-strength ✓ London forces.
OR London forces are similar / same. ✓✓
CO has stronger ✓ dipole–dipole forces ✓ in addition.
More energy is needed to overcome the stronger intermolecular forces between CO molecules. ✓
CO will have higher boiling point. ✓

QUESTION 3

3.1 (A reaction involving) the transfer of electrons ✓✓

3.2 3.2.1 $H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$ ✓

3.2.2 $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$ ✓

–1 in total for double arrows

3.3 DOUBLE ✓

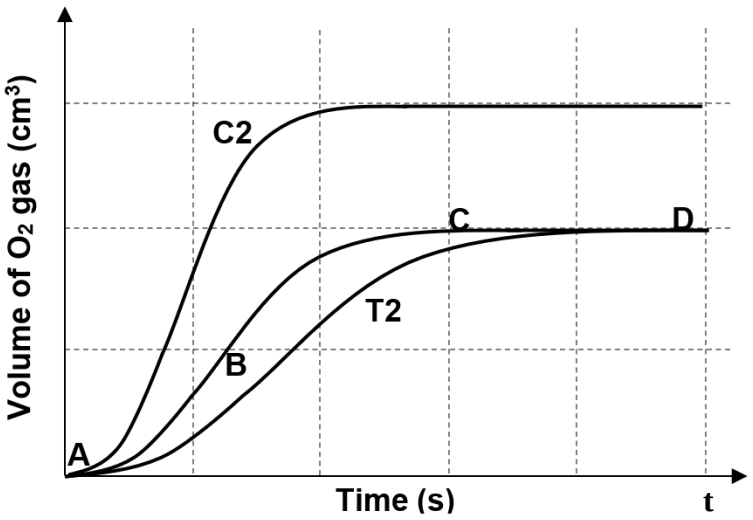
3.4 (Reactions that) transform chemical potential energy into thermal energy ✓✓
OR Reactions that result in a net release of energy. ✓

3.5 A substance that increases the rate of a reaction ✓ but remains unchanged at the end of the reaction. ✓

3.6 3.6.1 Rate is INCREASING ✓
Reaction is exothermic✓ ∴ temperature is increasing ✓

3.6.2 Rate is ZERO ✓ (reaction has stopped)
limiting reactant / H_2O_2 is used up / all the H_2O_2 has reacted ✓✓

3.7

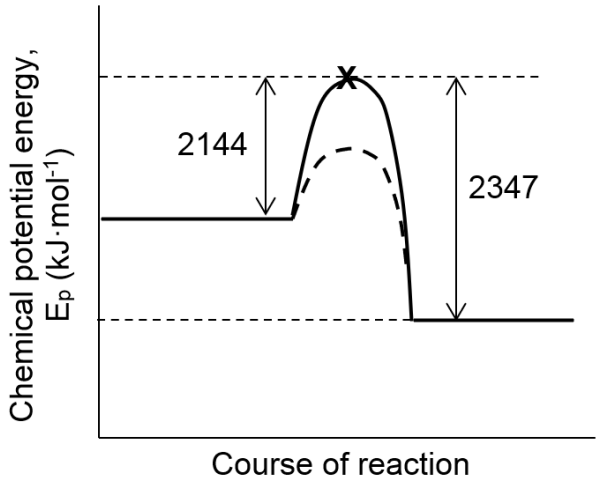


3.7.1 **C2**
steeper curve ✓
1,5 × amount of O_2 produced ✓

3.7.2 **T2**
Less-steep curve ✓
Same amount of O_2 produced ✓

3.8 more particles per unit volume ✓
More collisions ✓ per unit time
More effective collisions ✓ per unit time ✓
Rate increases ✓

3.9



3.9.1 A high-energy, unstable (temporary) transition state ✓ between the reactants and the products ✓

3.9.2 ***X*** *marked at top of energy peak* ✓

3.9.3 *Curve starts and ends at same point as original curve.* ✓
Peak is lower. ✓

3.9.4 The (amount of) energy released/given out ✓
OR: the activation energy for the reverse reaction

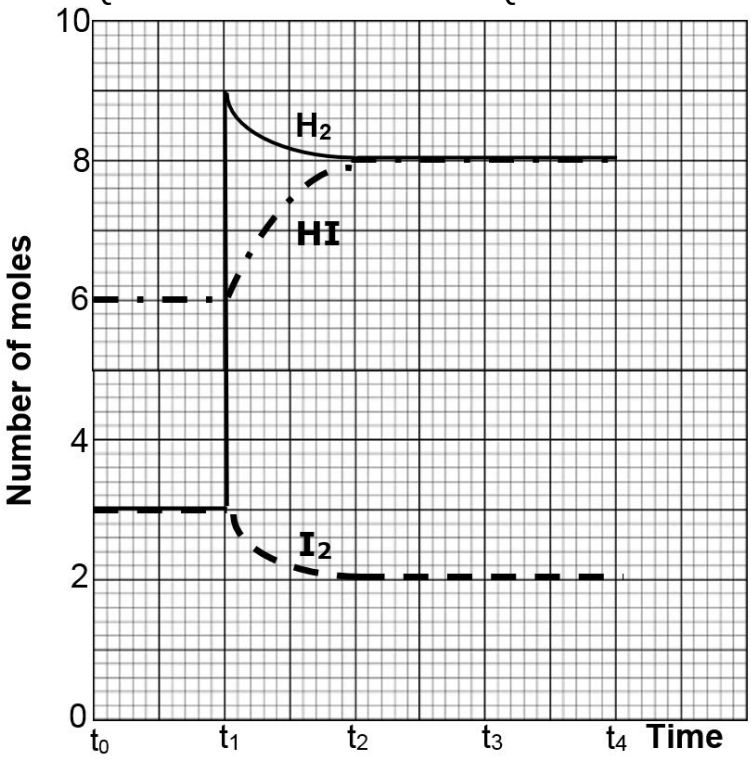
3.9.5 $\Delta H = E_{in} - E_{out}$ = 2 144 – 2 347 ✓ = – 203 kJ·mol^{-1} ✓

QUESTION 4

4.1 (6 moles of) H_2 was added. ✓✓ moles or concentration of H_2 increased / was increased ✓

Question 4.2 Question 4.5

4.2



- *t_0 to t_1 all correct and constant* ✓
- *At t_1, H_2 increases to 9* ✓
- *Between t_1 and t_2, H_2 gets to 8* ✓*, HI gets to 8* ✓*, I_2 gets to 2* ✓
- *t_2 to t_3 all constant* ✓

*If the transitions from **t_1** to **t_2** are incorrectly shown, take off max 1 mark.*

4.3
- The reaction that removes H_2 or decreases $[H_2]$ is favoured, ✓
- i.e. the forward reaction is favoured. ✓
- The amounts of (H_2 and) I_2 decrease ✓
- and the amount of HI increases. ✓

4.4 $K_c = \frac{[HI]^2}{[H_2][I_2]}$ top ✓ bottom ✓ (*or implied in calculation*)

Divide all moles by 2 to get concentration ✓
V cancels. If not used then max 4/6.

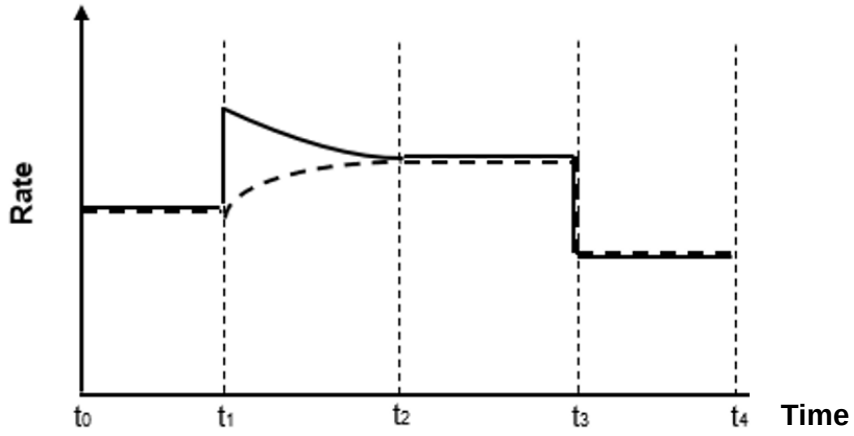
Before **t_1**:
$K_c = \frac{3^2}{(1,5)(1,5)} = 4$ ‘

After **t_2**:
$K_c = \frac{4^2}{(1)(4)} = 4$

Substitute (concentration values) × 2 ✓
Same correct answer (4) ✓
K_c does not change ∴ not a temperature change ✓

4.5 *No change to number of moles at **t_3*** ✓✓ (*See on graph above*.)

4.6



- ***t₀ – t₁*** *rates equal* ✓
- *At* ***t₁****, rate of forward increases* ✓
- ***t₂ – t₃*** *both rates equal and higher than between* t_0 *and* t_1 ✓
- *At* ***t₃*** *both rates decrease by same amount* ✓
- *then continue equal and lower* ✓

QUESTION 5

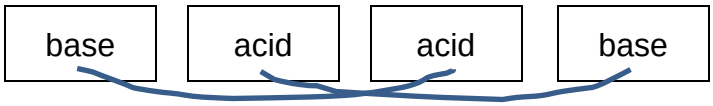
5.1 sodium ✓ thiosulfate ✓ (accept thiosulphate)

5.2 NaOH is a STRONG ✓ base that COMPLETELY ✓ DISSOCIATES ✓ in water.

5.3
- NaOH is a (giant) ionic solid. ✓ (accept if ionic bonds stated below)
- There are **many** ✓ **strong** ✓ ionic bonds / electrostatic / coulombic forces of attraction
- A lot of energy is needed to break/overcome the ionic bonds / them✓

5.4 5.4.1 A substance in which the hydrogen of an acid ✓has been replaced by a cation. ✓

5.4.2 $S^{2-}(aq) + H_2O(\ell) \rightleftharpoons HS^-(aq) + OH^-(aq)$



Labels ✓ *links* ✓

5.4.3 hydrolysis ✓

5.4.4 BASIC ✓ The $[OH^-]$ increases OR $[OH^-] > [H_3O^+]$ ✓
OR it is a salt of a strong base and a weak acid✓

5.4.5 FALSE ✓

5.5 5.5.1 $n(S) = \frac{m}{M}$ ✓ $= \frac{2,24}{32}$ (✓ *sub both*) = 0,07 mol

$n(NaOH) = cV$ ✓ $= 0,5 \times 0,3$ (✓ *sub both*) = 0,15 mol

0,07 mol S reacts with $0,07 \times \frac{6}{4}$ = 0,105 mol NaOH < 0,15 mol ✓

OR: 0,15 mol NaOH needs $0,15 \times \frac{4}{6}$ = 0,1 mol S > 0,07 mol ✓

∴ **S is limiting reagent** ✓

5.5.2 *Carry over error from 5.5.1 (must use the amounts that react)*
Calculate theoretical yield:

EITHER: 0,07 mol S (LR) produces $\frac{0,07}{4}$ ✓ = 0,0175 mol $Na_2S_2O_3$

OR: 0,105 mol NaOH produces $\frac{0,105}{6}$ ✓ = 0,0175 mol $Na_2S_2O_3$

Calculate actual yield and mass:
EITHER: $m(Na_2S_2O_3) = nM = 0,0175$✓ × 158 ✓ = **2,765 g**
Actual yield = 75% ✓ of 2,765 = **2,07 g** ✓

OR: Actual yield = 75%✓ of 0,0175 = **0,0131 mol** ✓
$m(Na_2S_2O_3) = nM = 0,0131 \times 158$ ✓ **= 2,07 g** ✓

QUESTION 6

6.1 6.1.1 $HC\ell + H_2O$✓ $\rightarrow H_3O^+ + C\ell^-$ ✓ *(–1 if double arrow)*

6.1.2 $HC\ell$ is a strong (monoprotic) acid **OR** $HC\ell$ ionises completely. ✓
The $[H_3O^+]$ **OR** $[H^+]$ = $[HC\ell]$ = 1 mol·dm^{-3}✓

6.2 6.2.1 $(COOH)_2$ **OR** $H_2C_2O_4$ ✓

6.2.2 Oxalic acid is a weak acid **OR** oxalic acid only ionises partially. ✓
The $[H_3O^+]$ **OR** $[H^+]$ will be less than 1 mol·dm^{-3} ✓

6.3 Pressure **of H_2(g)** / gas ✓ = 1 atm **OR** 101,3 kPa **OR** 1,01 × 10^5 Pa ✓

6.4 6.4.1 (SHE is the) ANODE✓

6.4.2 pH decreases ∴ $[H_3O^+]$ **OR** amount of H_3O^+ increases ✓ ∴ oxidation (of H_2 to H^+) is occurring ✓

6.5 $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ *(or alternative) OR implied*✓
1,42 ✓ = $E^{\theta}_{cathode} - 0$ ✓
$E^{\theta}_{cathode}$ = 1,42 V
∴ X is **Au** (gold) ✓

6.6 6.6.1 NO CHANGE ✓

6.6.2 INCREASE ✓

6.7 6.7.1 NO CHANGE ✓

6.7.2 DECREASE ✓

QUESTION 7

7.1 bauxite ✓ *(accept other correct answers)*

7.2 $A\ell_2O_3 \xrightarrow{heat} 2A\ell^{3+}$ ✓+ $3O^{2-}$ ✓
State symbols not required.

7.3 $n = m/M$ ✓ = 5 / (102 ✓) = 0,049 mol
$N = nN_A = 0{,}049 \times 6{,}02 \times 10^{23}$ ✓= $2{,}95 \times 10^{22}$
N(ions) = 5 ✓ × $2{,}95 \times 10^{22} = 1{,}48 \times 10^{23}$ ✓

7.4 **2**$A\ell_2O_3 \rightarrow$ **4**Aℓ✓ + **3**O_2 ✓ bal ✓
State symbols not required.

7.5 7.5.1 to lower the melting point (of $A\ell_2O_3$)✓

7.5.2 Aluminium ions are stronger oxidising agents (than sodium ions), ✓
Therefore they are reduced instead/preferentially. ✓

7.6 ANODES ✓

7.7 n(Aℓ) = m/M = 5×10^4 / 27 ✓= 1851,85 mol
$n(e^-)$ = 1851,85 × 3 ✓= 5555,56 mol
EITHER: $q = n_eF$ = 5555,56 × 96 500 ✓= $5{,}361 \times 10^8$ C
$q = It$ ✓ ∴ $t = q / I$ = $5{,}361 \times 10^8 / 1{,}5 \times 10^5$ ✓= 3574,07 s ✓

OR: $N_{e^-} = n_{e^-}N_A = 5555{,}56 \times 6{,}02 \times 10^{23} = 3{,}34 \times 10^{27}$ electrons
$q = N_{e^-}q_{e^-}$ = 3,34 x 10^{27} × $1{,}6 \times 10^{-19}$ ✓ = $5{,}351 \times 10^8$ C
$q = It$ ✓∴ t = q / I = 3567,41 s ✓

- *Calculation of n(Aℓ)* ✓
- *Apply mole ratio to get n(electrons)* ✓
- *Use 96500 C to determine quantity of charge* ✓
- *Use formula q = It* ✓
- *Substitute into formula q = It* ✓
- *Final answer* ✓

QUESTION 8

8.1 8.1.1 The atom or group of atoms✓ that form the centre of chemical activity in the molecule. ✓

8.1.2 hydroxyl ✓

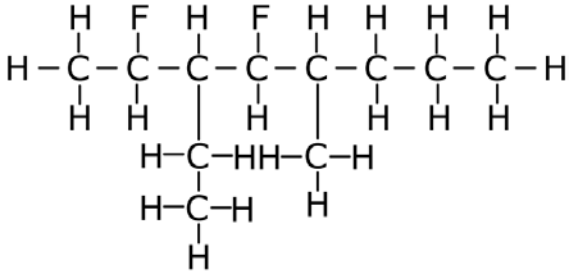
8.1.3 2,2-dimethyl✓butan✓-1-ol ✓

8.1.4 There is no H on the C adjacent to the C with OH attached ✓✓

8.1.5 CHAIN✓ isomer

8.1.6 The straight-chain compound ($CH_3(CH_2)_5OH$) has a greater (contact) surface area / longer chain ✓
It will form more/larger temporary dipoles ✓
The London forces will be stronger. ✓
More energy is needed to overcome them. ✓

8.2



- *8 C chain ✓*
- *Ethyl on C3 ✓*
- *Methyl on C5 ✓*
- *2 × F on C2 and C4 ✓*

Missing H's –1

QUESTION 9

9.1 9.1.1 (a) A and D ✓✓
(b) H and I ✓✓
(c) B and G ✓✓
(d) J ✓
(e) E ✓
(f) J ✓

9.1.2 (a) methyl✓propene✓ (accept 2–methylprop–1–ene) (one word)
(b) pentyl ✓ methanoate ✓

9.2 9.2.1 $CH_3CH_3 + 2C\ell_2 \xrightarrow{uv\ light} CH_2C\ell CH_2C\ell$ **OR** $CHC\ell_2CH_3$ ✓ + **2**$HC\ell$ ✓ bal ✓
Substitution ✓

9.2.2 $CH_3COOH + CH_3CH_2CH_2OH \xrightarrow{conc.\ H_2SO_4} CH_3COOCH_2CH_2CH_3$ ✓ + H_2O ✓
Esterification ✓

-1 in total if structural formulae used

9.3 9.3.1 **X** is C_4H_{10} ✓

9.3.2 Catalytic ✓ cracking ✓

Total: 200 marks