NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 2022

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 D
1.3 C
1.4 B
1.5 A
1.6 B
1.7 D
1.8 D
1.9 B
1.10 C **[20]**

QUESTION 2

2.1 $4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$
LHS ✓
RHS ✓
Balancing ✓
States ✓ (4)

2.2
- Ionic bonding ✓
- involving the transfer of electrons (OR sodium loses electrons and oxygen gains electrons) ✓ (2)

2.3
- In order to melt sodium oxide, many ✓ (very) strong ✓ ionic bonds ✓ must be broken
- This requires a large amount of energy ✓ (4)

2.4 2.4.1 $Na^+ + e^- \rightarrow Na$ ✓✓ (2)

2.4.2
- In a solid, the sodium and oxide ions are fixed in position in the crystal lattice ✓
- When molten, the ions are free to move ✓ (2)

2.5 2.5.1 $n(Na_2O) = \frac{m}{M}$ ✓

$n(Na_2O) = \frac{(50)}{(62)}$ ✓

$\boldsymbol{n(Na_2O) = 0,81\ mol}$ ✓ (3)

2.5.2 The amount of solute per unit volume of solution. ✓✓ (2)

2.5.3
- $n(OH^-) = n(NaOH) = (0,81) \times \frac{2}{1}$ ✓ $= 1,62$ mol
- $c(OH^-) = \frac{n}{V}$ ✓ $= \frac{(1,62)}{(0,5)}$ ✓ (sub) ✓ (conversion of V)
- $c(OH^-) =$ **3,24 mol·dm⁻³** ✓

(coe from Question 2.5.1) (5)

2.5.4 $K_w = [H_3O^+][OH^-]$ ✓

$(10^{-14}) = [H_3O^+](3,24)$ ✓

$\boldsymbol{[H_3O^+] = 3,09 \times 10^{-15}\ mol \cdot dm^{-3}}$ ✓

(coe from Question 2.5.3) (3)

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QUESTION 3

3.1 3.1.1 Average rate = $\frac{27,6}{3^3}$ ✓ = **1,02 mg·min⁻¹** ✓ (2)

3.1.2
- Bromine is the limiting reagent ✓
- because there is rhodium left over after the reaction has come to completion ✓ (2)

3.1.3 10 min (± 2 min) ✓ (1)

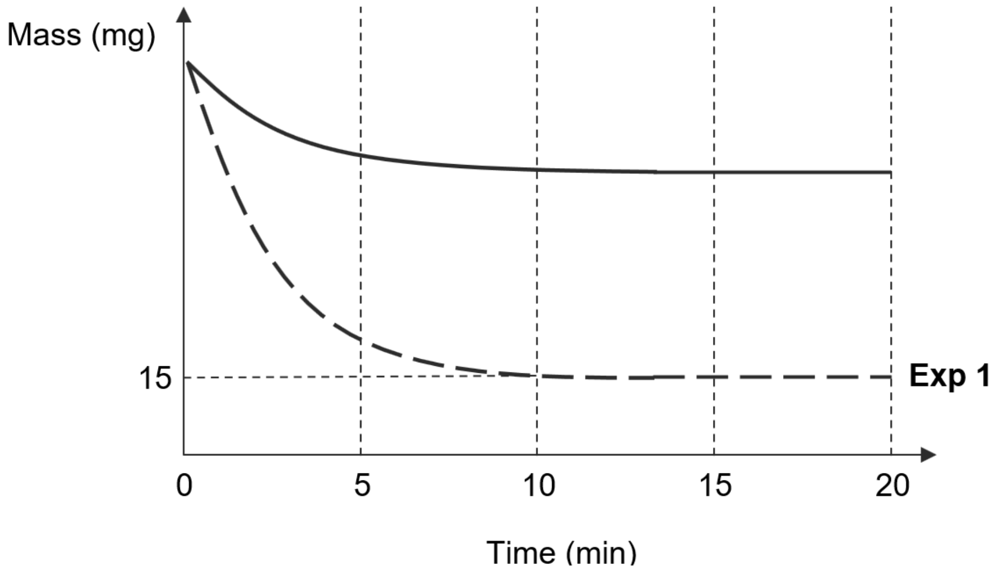
3.1.4 Average rate $= \frac{\Delta m}{\Delta t}$

$(27,6) = \frac{m_i - (15)}{(10)}$ ✓✓

$\boldsymbol{m_i} = \mathbf{291\ mg}$ ✓

coe from 3.1.3 (3)

3.1.5



Lower gradient ✓
Approximately one third change in mass ✓ (2)

3.1.6
- A higher concentration in Experiment 1 means that there is a greater number of particles per unit volume ✓
- This causes a greater number of collisions per unit time ✓
- Thus, there is a greater number of effective collisions per unit time ✓
- and so Experiment 1 has a higher reaction rate ✓ (4)

3.2 3.2.1 The net change in chemical potential energy of the system. ✓✓ (2)

3.2.2 Negative ✓ (1)

3.2.3
- The reaction rate will increase (uncontrollably) ✓
- This might cause the water to boil OR it might cause the reaction to finish too early OR be difficult to measure ✓ (2)

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QUESTION 4

4.1 4.1.1 $K_c = \frac{[C_2H_6]^2[O_2]}{[C_2H_4]^2[H_2O]^2}$ ✓ (top) ✓ (bottom) (2)

4.1.2 $K_c = \frac{[C_2H_6]^2[O_2]}{[C_2H_4]^2[H_2O]^2}$

$(0,025) = \frac{[C_2H_6]^2(0,08)}{(0,4)^2(0,28)^2}$ ✓✓

$[C_2H_6] = 0,0626\ \text{mol·dm}^{-3}$

$\therefore n(C_2H_6) = cV = (0,0626)(3)$ ✓ $=$ **0,19 mol** ✓ (4)

4.1.3 The pressure was decreased (OR the volume was increased) ✓✓
(only 1 mark for saying a change in pressure/volume) (2)

4.1.4 When an **external stress** (change in pressure, temperature or concentration) **is applied to a system in dynamic chemical equilibrium**, the **equilibrium point will change** in such a way as to **counteract the stress**. ✓✓
All three bolded statements for two marks. (2)

4.1.5
- Stress: increase in temperature
- Response: Le Châtelier's principle predicts the system will counteract the stress and decrease the temperature (✓)
- Thus, the endothermic reaction is (initially) favoured ✓ as it consumes heat (✓)
- From the graph, we can see that the concentration of reactants (C_2H_4 + H_2O) decreased and products (C_2H_6 + O_2) increased ✓
- Therefore, the forward reaction was favoured ✓
- The forward reaction must be **endothermic** ✓ (5)

4.1.6 No effect ✓✓ (2)

4.2 4.2.1 No effect ✓✓ (2)

4.2.2 pH is a measure of hydronium ion concentration ✓ at 25 °C. ✓ (2)

4.2.3
- Stress: increase in concentration of Ca^{2+}
- Le Châtelier's principle predicts the system will respond in order to decrease the concentration of Ca^{2+} (✓)
- Therefore, the reverse reaction is favoured ✓ as it consumes Ca^{2+} (✓)
- The concentration of OH^- decreases OR the concentration of H_3O^+ increases ✓
- Therefore, the pH decreases ✓ (4)

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QUESTION 5

5.1 Any TWO of the following:

- Morgan used tap water ✓ instead of distilled water ✓
- Morgan used a beaker ✓ instead of a volumetric flask ✓
- Morgan added the HCN after the water was filled to the mark ✓ instead of before ✓ (4)

5.2 An acid that only ionises partially ✓ in an aqueous solution. ✓ (2)

5.3 The acid can only donate one proton. ✓ (1)

5.4 The reaction of a molecular substance with water ✓ to produce ions. ✓ (2)

5.5 $HCN + H_2O \rightleftharpoons$ ✓ $CN^- + H_3O^+$ ✓(RHS) (2)

5.6 *Concentrations*:

Reaction/Ratio	HCN	+	H_2O	$\rightleftharpoons$	CN^-	+	H_3O^+	
Initial conc	0,05				0		0	
Change in conc	$-x$				$+x$		$+x$	✓
Equilibrium conc	$0,05 - x$				x		x	✓

(ignore any value in the H_2O column)

$$K_a = \frac{[CN^-][H_3O^+]}{[HCN]} \checkmark\checkmark$$

$$(6,2\times10^{-10}) = \frac{(x)(x)}{(0,05-x)} \checkmark\checkmark \quad \text{OR} \quad (6,2\times10^{-10}) = \frac{(x)(x)}{(0,05)}$$

$$[H_3O^+] = x = \mathbf{5,57\times10^{-6}\ mol{\cdot}dm^{-3}}$$ (6)

5.7 5.7.1

- $n_a = c_aV_a$ ✓ $= (0,05)(0,025)$ ✓ (sub) $= 0,00125$ mol
- $n_b = n_a$ ✓ $= 0,00125$ mol
- $c_b = \frac{n_b}{V_b} = \frac{(0,00125)}{(0,03344)}$ ✓ $= \mathbf{0,04\ mol{\cdot}dm^{-3}}$ ✓

(5)

5.7.2 Yellow ✓ (1)

5.7.3 Phenolphthalein ✓✓ (2)

5.7.4 A substance in which the hydrogen of an acid has been replaced by a cation. ✓✓ (2)

5.7.5 $CN^- + H_2O \rightleftharpoons HCN + OH^-$

LHS ✓

RHS ✓

Reversible arrow ✓ (3)

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QUESTION 6

6.1 To provide a solid **surface** for electron transfer/loss ✓ (1)

6.2 The gain of electrons. ✓ (1)

6.3 $2C\ell^- \rightarrow C\ell_2 + 2e^-$ ✓✓ (2)

6.4 $2Au^{3+} + 6C\ell^- \rightarrow 2Au + 3C\ell_2$
LHS ✓
RHS ✓
Balancing ✓ (3)

6.5 6.5.1
- Completes the circuit ✓
- Maintains electrical neutrality ✓ (2)

6.5.2 (a) Decreases ✓✓ (2)

(b) No effect ✓✓ (2)

6.6 No ✓
The graph is not a straight line (through the origin) ✓ (2)

6.7 $E^{0}_{cell} = E^{0}_{cathode} - E^{0}_{anode}$ ✓
$E^{0}_{cell} = (+1{,}42) - (+1{,}36)$ ✓✓
$E^{0}_{cell} =$ **0,06 V** ✓ (4)

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QUESTION 7

7.1 Electrical (potential) energy to chemical (potential) energy ✓✓ (2)

7.2 Q ✓ (1)

7.3 $2Br^- \rightarrow Br_2 + 2e^-$ ✓✓ (2)

7.4 7.4.1 The electrode ✓ at which reduction occurs. ✓ (2)

7.4.2 A substance that accepts electrons. ✓✓ (2)

7.4.3 Cu ✓ (1)

7.4.4
- Cu^{2+} ✓ is a stronger oxidising agent ✓ than H_2O ✓ (OR H_2O is a weaker oxidising agent than Cu^{2+})
- Therefore, Cu^{2+} is more likely to be reduced ✓ (OR H_2O is less likely to be reduced OR the rate of the Cu^{2+} reduction is much higher OR the rate of the H_2O reduction is much lower) (4)

7.4.5 C ✓✓ (2)

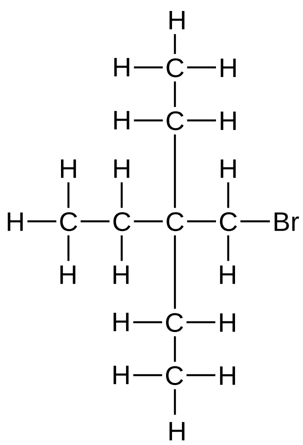
[16]

QUESTION 8

8.1 Haloalkanes (OR alkyl halides) ✓ (1)

8.2 2−chlorobutane
2−chloro ✓
but ✓
ane ✓ (3)

8.3



✓ longest carbon chain: butane
✓ 2 ethyl groups on C2
✓ Br on C1 (3)

8.4 1−bromodiethylbutane (OR 1−bromo−2,2−diethylbutane)
1−bromo ✓
diethyl ✓ (OR 2,2−diethyl)
but ✓
ane ✓ (4)

8.5 They have the same molecular formula ✓ but different structural formulas (OR different structures). ✓ (2)

8.6 Chain ✓ (1)

8.7
- Both compounds B and C have London forces (only) ✓
- Compound C has a larger interacting surface ✓
- leading to larger induced dipoles ✓
- and thus stronger London forces (IMFs) ✓
- More energy is required to overcome the intermolecular forces (OR separate the particles) in compound C ✓
- Thus, compound C has a higher boiling point ✓ (6)

8.8 8.8.1 Substitution ✓ (1)

8.8.2 $(C_2H_5)_3CCH_2Br + NaOH \rightarrow (C_2H_5)_3CCH_2OH + NaBr$
NaBr ✓
$(C_2H_5)_3CCH_2OH$ ✓✓ (3)

8.9 8.9.1 Dehydrohalogenation (OR dehydrobromination) ✓ (1)

8.9.2 Double carbon-carbon bond ✓ (1)

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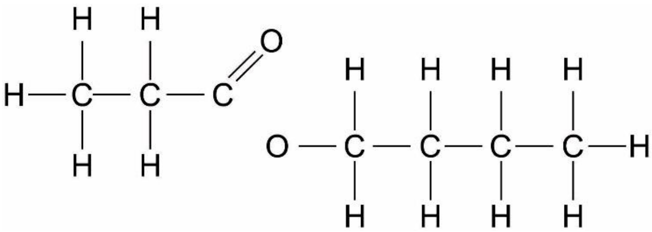
QUESTION 9

9.1 H_2SO_4 ✓ (1)

9.2 Propanoic acid ✓✓ (2)

9.3 Alkenes ✓✓ (2)

9.4



butyl ✓ prop ✓ functional group ✓ (3)

9.5 9.5.1
- Combustion reactions are highly exothermic OR they release large amounts of energy ✓
- for a small amount of fuel (OR which is used for heat, light, or to do some sort of work by the engine OR they are clean fuels) ✓ (2)

9.5.2 $C_4H_{10}O + 6O_2 \rightarrow 4CO_2 + 5H_2O$
$C_4H_{10}O$ ✓
O_2 ✓
$CO_2 + H_2O$ ✓
Balancing ✓ (4)

9.6 9.6.1 Cracking ✓ (1)

9.6.2 $C_{12}O_{26} \rightarrow C_7H_{16}$ ✓ + C_3H_6 ✓ + C_2H_4 ✓ (3)

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Total: 200 marks