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NATIONAL SENIOR CERTIFICATE EXAMINATION  
MAY 2022

**PHYSICAL SCIENCES: PAPER II**  
**MARKING GUIDELINES**

Time: 3 hours

200 marks

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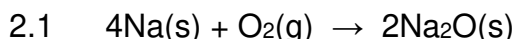
These marking guidelines are prepared for use by examiners and sub-examiners, all of whom are required to attend a standardisation meeting to ensure that the guidelines are consistently interpreted and applied in the marking of candidates' scripts.

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**

- 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

**QUESTION 2**

LHS

RHS

Balancing

States

- 2.2
- Ionic bonding
  - involving the transfer of electrons (OR sodium loses electrons and oxygen gains electrons)
- 2.3
- In order to melt sodium oxide, many (very) strong ionic bonds must be broken
  - This requires a large amount of energy



- 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

2.5 2.5.1  $n(\text{Na}_2\text{O}) = \frac{m}{M}$

$$n(\text{Na}_2\text{O}) = \frac{(50)}{(62)}$$

$$n(\text{Na}_2\text{O}) = 0,81 \text{ mol}$$

2.5.2 The amount of solute per unit volume of solution.

2.5.3

- $n(\text{OH}^-) = n(\text{NaOH}) = (0,81) \times \frac{2}{1} = 1,62 \text{ mol}$
- $c(\text{OH}^-) = \frac{n}{V} = \frac{(1,62)}{(0,5)} \text{ (sub) (conversion of V)}$
- $c(\text{OH}^-) = 3,24 \text{ mol} \cdot \text{dm}^{-3}$   
(coe from Question 2.5.1)

2.5.4  $K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$

$$(10^{-14}) = [\text{H}_3\text{O}^+](3,24)$$

$$[\text{H}_3\text{O}^+] = 3,09 \times 10^{-15} \text{ mol} \cdot \text{dm}^{-3}$$

(coe from Question 2.5.3)

**QUESTION 3**

3.1 3.1.1 Average rate =  $\frac{27,6}{3^3} = 1,02 \text{ mg} \cdot \text{min}^{-1}$

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

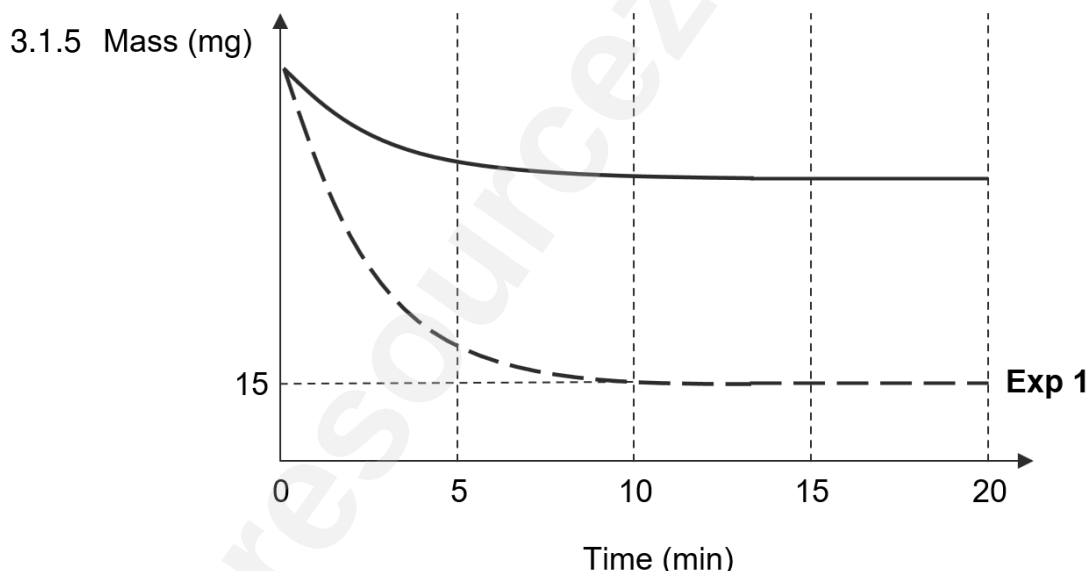
3.1.3 10 min ( $\pm 2$  min)

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

$$(27,6) = \frac{m_i - (15)}{(10)}$$

$$m_i = 291 \text{ mg}$$

coe from 3.1.3



Lower gradient

Approximately one third change in mass

- 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

3.2 3.2.1 The net change in chemical potential energy of the system.

3.2.2 Negative

- 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

## QUESTION 4

4.1 4.1.1  $K_c = \frac{[\text{C}_2\text{H}_6]^2 [\text{O}_2]}{[\text{C}_2\text{H}_4]^2 [\text{H}_2\text{O}]^2}$  (top) (bottom)

4.1.2  $K_c = \frac{[\text{C}_2\text{H}_6]^2 [\text{O}_2]}{[\text{C}_2\text{H}_4]^2 [\text{H}_2\text{O}]^2}$

$(0,025) = \frac{[\text{C}_2\text{H}_6]^2 (0,08)}{(0,4)^2 (0,28)^2}$

$[\text{C}_2\text{H}_6] = 0,0626 \text{ mol} \cdot \text{dm}^{-3}$

$\therefore n(\text{C}_2\text{H}_6) = cV = (0,0626)(3) = 0,19 \text{ mol}$

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

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.

- 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 ( $\text{C}_2\text{H}_4 + \text{H}_2\text{O}$ ) decreased and products ( $\text{C}_2\text{H}_6 + \text{O}_2$ ) increased
  - Therefore, the forward reaction was favoured
  - The forward reaction must be **endothermic**

4.1.6 No effect

4.2 4.2.1 No effect

4.2.2 pH is a measure of hydronium ion concentration at 25 °C.

- 4.2.3
- Stress: increase in concentration of  $\text{Ca}^{2+}$
  - Le Châtelier's principle predicts the system will respond in order to decrease the concentration of  $\text{Ca}^{2+}$
  - Therefore, the reverse reaction is favoured as it consumes  $\text{Ca}^{2+}$
  - The concentration of  $\text{OH}^-$  decreases OR the concentration of  $\text{H}_3\text{O}^+$  increases
  - Therefore, the pH decreases

**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

5.2 An acid that only ionises partially in an aqueous solution.

5.3 The acid can only donate one proton.

5.4 The reaction of a molecular substance with water to produce ions.

5.5  $\text{HCN} + \text{H}_2\text{O} \rightleftharpoons \text{CN}^- + \text{H}_3\text{O}^+$  (RHS)5.6 *Concentrations:*

| Reaction/Ratio   | HCN      | + | H <sub>2</sub> O | $\rightleftharpoons$ | CN <sup>-</sup> | + | H <sub>3</sub> O <sup>+</sup> |
|------------------|----------|---|------------------|----------------------|-----------------|---|-------------------------------|
| 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<sub>2</sub>O column)

$$K_a = \frac{[\text{CN}^-][\text{H}_3\text{O}^+]}{[\text{HCN}]}$$

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

$$[\text{H}_3\text{O}^+] = x = 5,57 \times 10^{-6} \text{ mol} \cdot \text{dm}^{-3}$$

5.7 5.7.1 •  $n_a = c_a V_a = (0,05)(0,025)$  (sub) = 0,00125 mol

$$\bullet \quad n_b = n_a = 0,00125 \text{ mol}$$

$$\bullet \quad c_b = \frac{n_b}{V_b} = \frac{(0,00125)}{(0,03344)} = 0,04 \text{ mol} \cdot \text{dm}^{-3}$$

5.7.2 Yellow

5.7.3 Phenolphthalein

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

5.7.5  $\text{CN}^- + \text{H}_2\text{O} \rightleftharpoons \text{HCN} + \text{OH}^-$ 

LHS

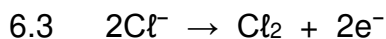
RHS

Reversible arrow

**QUESTION 6**

6.1 To provide a solid **surface** for electron transfer/loss

6.2 The gain of electrons.



LHS

RHS

Balancing

- 6.5 6.5.1
- Completes the circuit
  - Maintains electrical neutrality

6.5.2 (a) Decreases

(b) No effect

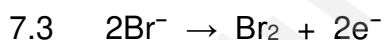
6.6 No  
The graph is not a straight line (through the origin)

6.7  $E_{\text{cell}}^0 = E_{\text{cathode}}^0 - E_{\text{anode}}^0$   
 $E_{\text{cell}}^0 = (+1,42) - (+1,36)$   
 $E_{\text{cell}}^0 = 0,06 \text{ V}$

**QUESTION 7**

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

7.2 Q



7.4 7.4.1 The electrode at which reduction occurs.

7.4.2 A substance that accepts electrons.

7.4.3 Cu

- 7.4.4
- $\text{Cu}^{2+}$  is a stronger oxidising agent than  $\text{H}_2\text{O}$  (OR  $\text{H}_2\text{O}$  is a weaker oxidising agent than  $\text{Cu}^{2+}$ )
  - Therefore,  $\text{Cu}^{2+}$  is more likely to be reduced (OR  $\text{H}_2\text{O}$  is less likely to be reduced OR the rate of the  $\text{Cu}^{2+}$  reduction is much higher OR the rate of the  $\text{H}_2\text{O}$  reduction is much lower)

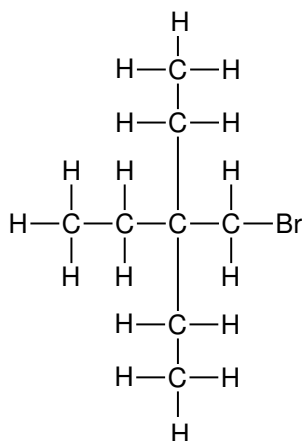
7.4.5 C

**QUESTION 8**

8.1 Haloalkanes (OR alkyl halides)

8.2 2-chlorobutane  
2-chloro  
but  
ane

8.3

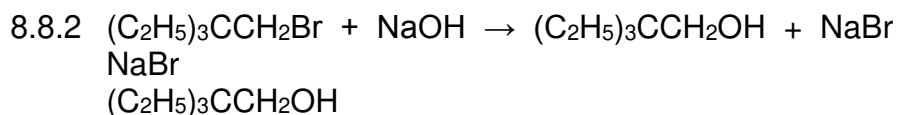
8.4 1-bromodiethylbutane (OR 1-bromo-2,2-diethylbutane)  
1-bromo  
diethyl (OR 2,2-diethyl)  
but  
ane

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

8.6 Chain

- 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

8.8 8.8.1 Substitution



8.9 8.9.1 Dehydrohalogenation (OR dehydrobromination)

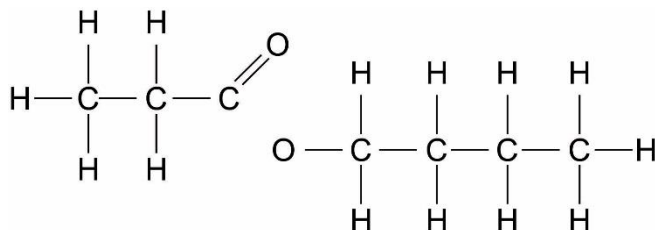
8.9.2 Double carbon-carbon bond

**QUESTION 9**9.1  $\text{H}_2\text{SO}_4$ 

9.2 Propanoic acid

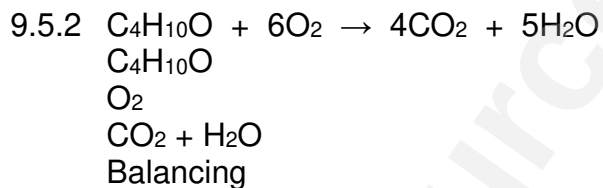
9.3 Alkenes

9.4



butyl prop functional group

- 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)



9.6 9.6.1 Cracking

**Total: 200 marks**