INTERNATIONAL SECONDARY 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

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

QUESTION 2

2.1 2.1.1 Pure/Non-polar Covalent.

2.1.2 Polar Covalent.

2.2 2.2.1 Both compounds have London forces between molecules.
Bromine has a greater molar mass/electron cloud density.
More energy is required to overcome stronger forces.

2.2.2 H_2S has dipole-dipole forces.
H_2O has stronger hydrogen bonds.
More energy is required to overcome stronger forces.

2.3 2.3.1 Electrons are transferred and ions are held together by electrostatic forces.

2.3.2 Sea of delocalised electrons hold positive kernels together by electrostatic forces.

2.4 Copper has metallic bonding and conducts electricity/current via free electrons in any phase.
KCℓ has ionic bonding and conducts electricity/current via free ions in molten or aqueous phase.

QUESTION 3

3.1 Reactions which transform chemical potential energy into thermal energy.

3.2 The reaction is exothermic and so the temperature of the reaction mixture increases, which increases the rate of the reaction.

3.3 The change in concentration per unit time of either a reactant or product.

3.4 The colliding reactant particles must have:

- the correct orientation
- sufficient energy to overcome activation energy (accept collide hard enough)

3.5 [HCℓ] decreases.
Fewer (HCℓ) particles per unit volume.
Fewer collisions occur per second.
Fewer effective collisions occur per second.

3.6 Increase temperature.
Increase [HCℓ].
Crush Na_2CO_3 into fine powder. (Any two answers)

3.7 CO_2: $n = \frac{V}{V_m}$

$= \frac{0,019}{22,4}$

$= 8,48 \times 10^{-4}$ mol

CO_2 : HCℓ
1 : 2
$8,48 \times 10^{-4} : 1,70 \times 10^{-3}$ mol

3.8 HCℓ : Na_2CO_3 (or $CO_2 : Na_2CO_3 = 1:1$)
2 : 1
$1,70 \times 10^{-3} : 8,48 \times 10^{-4}$ mol

Na_2CO_3: $n = \frac{n}{M}$

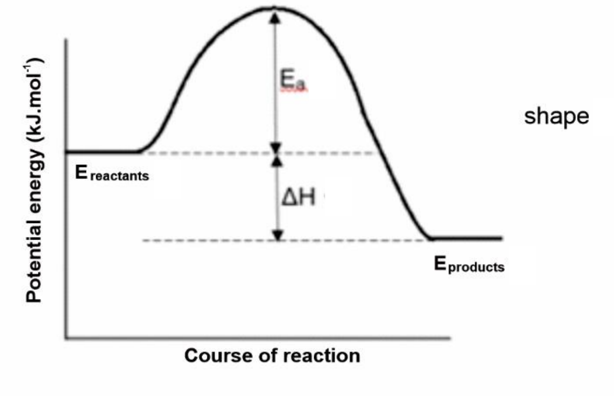
$8,48 \times 10^{-4} = \frac{m}{106}$

$m = 0,09$ g

$\%\text{ purity} = \frac{0,09}{0,2} \times 100$

$= 45,05\%$ (44,75%, if a rounded value used)

3.9



shape

QUESTION 4

4.1 One in which mass is conserved inside the system, but energy can enter or leave the system freely.

4.2 $$Kc = \frac{\left[Co\left(NH_3\right)_6{}^{2+}\right]}{\left[Co\left(H_2O\right)_6{}^{2+}\right]\left[NH_3\right]^6}$$

4.3

	$Co(H_2O)_6$	NH_3	$Co(NH_3)_6$	H_2O
Ratio	1	6	1	6
Initial	2,8	5,6	0	0
Change	–0,67	–4	+0,67	+4
Equilibrium	2,13	1,6	0,67	4

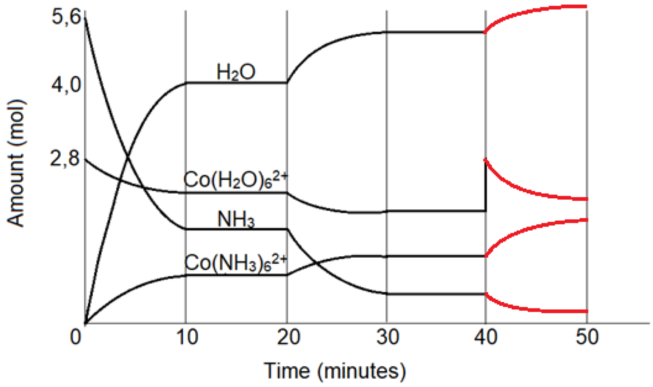
initial values
change values

$$Kc = \frac{(0{,}67)}{(2{,}13)(1{,}6)^6}$$
$$= 0{,}019$$

4.4 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.

4.5 Increased.
More products formed while the amount of reactants decreased.
Therefore, the forward endothermic reaction was favoured.
To restore equilibrium, the system responded by favouring the reaction that lowers the energy.

4.6



4.7 No change.

QUESTION 5

5.1 5.1.1 An acid that can only donate 1 proton/H^+ ion.

5.1.2 An acid that completely ionises in an aqueous solution and the solution has a high water-to acid ratio.

5.1.3 $\underset{\text{acid}}{HNO_3} + \underset{\text{base}}{H_2O} \rightarrow \underset{\text{base}}{NO_3^-} + \underset{\text{acid}}{H_3O^+}$

reactants labels
products labels
correctly linked
-1 if double arrow used

5.1.4 H_2O.

5.1.5 $HNO_3 : H_3O^+$
1 : 1
0,1 : 0,1 $mol.dm^{-3}$

$K_w = [H_3O]^+[OH^-]$
$1 \times 10^{-14} = (0,1)[OH^-]$
$[OH^-] = 1 \times 10^{-13}\ mol.dm^{-3}$

5.1.6 Increase.

5.2 5.2.1 NH_4^+ – strong.
$C\ell^-$ – weak.

5.2.2 Acidic.

5.2.3 $NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+$

5.2.4 $\dfrac{c_aV_a}{c_bV_b} = \dfrac{n_a}{n_b}$

$\dfrac{c_a(0{,}025)}{0{,}3(0{,}0125)} = \dfrac{1}{1}$ (volumes may be given in cm^3)

$c_a = 0{,}15\ mol.dm^{-3}$

OR

$n = cV$
$= 0{,}3\ (0{,}0125)$
$= 0{,}00375$ mol

$c = \dfrac{n}{v}$

$C_a = \dfrac{0{,}00375}{0{,}025}$
$= 0{,}15\ mol.dm^{-3}$

QUESTION 6

6.1 6.1.1 A cell that involves a spontaneous redox reaction that converts chemical energy into electrical energy.

6.1.2 A to B.

6.1.3 Darker.
More blue Cu^{2+} ions are deposited in the solution.
$Cu \rightarrow Cu^{2+} + 2e^-$

6.1.4 $Cu(s) \mid Cu^{2+}(aq) \parallel C\ell_2(g) \mid C\ell^-(aq) \mid Pt(s)$

6.1.5 $q = It$
$= 2{,}5(1\ 800)$
$= 4\ 500\ C$

$q = nF$
$4\ 500 = n(96\ 500)$
$n = 0{,}0466$ mol (or 0.0467, if q_e and N_A are used separately)

$e^- : C\ell_2$
2 : 1
0,0466 : 0,0233 mol

$V = nV_m$
$= 0{,}0233\ (24)$
$= 0{,}56\ dm^3$

6.2 6.2.1 A reaction involving the transfer of electrons.

6.2.2 Gain of electrons.

6.2.3 $Br_2 + 2e^- \rightarrow 2Br^-$

6.2.4 $S^{2-} \rightarrow S + 2e^-$

OR

$H_2S \rightarrow S + 2H^+ + 2e^-$

6.2.5 Substance that donates electrons.

6.2.6 S^{2-} or H_2S

6.2.7 H^+

6.2.8 Spontaneous.

QUESTION 7

7.1 B

7.2 $Cr^{3+} + 3e^{-} \rightarrow Cr$

7.3 It stays the same.

7.4 Cr^{3+} ions are replenished at the anode or rate of oxidation = rate of reduction.
$Cr \rightarrow Cr^{3+} + 3e^{-}$

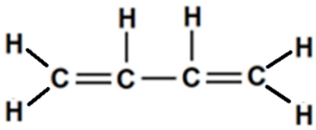
7.5 H_2O is a stronger oxidising agent than $A\ell^{3+}$ and will rather reduce at the cathode.

QUESTION 8

8.1 8.1.1 A series of similar compounds, which have the same functional group and have the same general formula, in which each member differs from the previous one by a single CH_2 unit.

8.1.2 Alkenes.

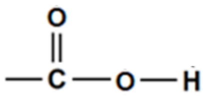
8.1.3



8.1.4 It is a substance with the same molecular formula but a different structural formula.

8.1.5 Buta-1,2-diene

8.2 8.2.1 Carboxyl group.



8.2.2 The melting points increase with an increase in chain length/molar mass.

8.2.3 Longer chains provide more bonding sites.
Greater electron cloud density.
More / stronger London forces (*not* hydrogen bonds).
More energy is required to overcome forces.

8.3 8.3.1 C_6H_{12}: $n = \frac{m}{n}$

$= \frac{126}{84}$

$= 1,5$ mol

O_2: $n = \frac{m}{M}$

$= \frac{960}{32}$

$= 30$ mol

$C_6H_{12} : O_2$
2 : 18
3,33 : 30

3,33 mol C_2H_{12} is required but only 1,5 mol is available; therefore, C_2H_{12} is limiting and O_2 is in excess.

8.3.2 $C_6H_{12} : CO_2$
2 : 12
1,5 : 9

$V = nV_m$
$= 9(22,4)$
$= 201,6\ dm^3$

QUESTION 9

9.1 But-1-ene.

9.2 C

9.3 The reaction would not take place, and the brown colour of bromine would remain.

9.4 Hydrohalogenation.

9.5 Substitution.

9.6 $CH_2BrCH_2CH_2CH_3 + NaOH_{(aq)} \rightarrow CH_2OHCH_2CH_2CH_3 + NaBr$

9.7 The haloalkane would undergo elimination forming butene.

9.8 Butyl pentanoate.

9.9 $C_4H_9OH + 6O_2 \rightarrow 4CO_2 + 5H_2O$

Total: 200 marks