INTERNATIONAL SECONDARY CERTIFICATE EXAMINATION
NOVEMBER 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 C
1.2 B
1.3 D
1.4 B
1.5 A
1.6 D
1.7 B
1.8 C
1.9 C
1.10 A

QUESTION 2

2.1 Strong acid

2.2 HSO_4^- OR hydrogen sulfate ion

2.3 2.3.1 The SI unit for amount of substance.

2.3.2 $n(H_2SO_4) = cV$
$n(H_2SO_4) = (0,15)\ (0,6)$
$n(H_2SO_4) = 0,09$ mol

2.3.3 $m_{pure} = (11,2)(0,8) = 8,96$ g

$$n(KOH) = \frac{m}{M}$$
$$n(KOH) = \frac{8,96}{56}$$
$n(KOH) = 0,16$ mol

2.3.4 ***POSITIVE MARKING FROM QUESTIONS 2.3.2 AND 2.3.3***

OPTION 1
H_2SO_4 : KOH
1 : 2
0,09 mol : 0,18 mol

Therefore, KOH is the limiting reagent and H_2SO_4 is in excess as 0,16 mol is less than the needed 0,18 mol. Therefore, the solution is acidic.

OPTION 2
H_2SO_4 : KOH
1 : 2
0,08 mol : 0,16 mol

H_2SO_4 is in excess as 0,08 mol used is less than 0,09 mol available. Therefore, the solution is acidic.

2.3.5 ***POSITIVE MARKING FROM QUESTIONS 2.3.2–2.3.4***

KOH : K_2SO_4
2 : 1
$n(K_2SO_4) = ½(0,16) = 0,08$ mol

$m(K_2SO_4) = nM$
$m(K_2SO_4) = (0,08)(174)$
$m(K_2SO_4) = 13,92$ g

Use of 174 g.mol^{-1}

2.3.6 A measure of the extent of a reaction generally measured by comparing the amount of product against the amount of product that is possible.

2.3.7 ***POSITIVE MARKING FROM QUESTION 2.3.5***

$$\text{Percentage yield} = \frac{\text{Experimental yield}}{\text{Theoretical yield}} \times 100$$

$$0,75 = \frac{\text{Experimental yield}}{13,92}$$

Experimental yield = 10,44 g

QUESTION 3

3.1 The change in concentration per unit time of (either) a reactant / product.

3.2 Temperature increase
OR
increase in the concentration of methanol/CH_3OH

3.3 0–15 minutes

3.4 $$\text{Average rate of reaction} = -\frac{\Delta c}{\Delta t}$$

$$\text{Average rate of reaction} = -\frac{1,10 - 1,45}{(55 - 15) \times 60}$$

Average rate of reaction = $1,46 \times 10^{-4}$ mol.dm^{-3}.s^{-1}

(3/4 if not scientific notation, but correct)

3.5
- The number of particles per unit volume decreases.
- Leads to fewer collisions (per unit time).
- Fewer effective collisions per unit time.

*(Must use per unit time at least once)

3.6 $\Delta c(HC\ell) = 1,90 - 0,60 = 1,30\ mol.dm^{-3}$

$n(HC\ell)_{reacted} = cV$
$n(HC\ell)_{reacted} = 1,30(0,06)$
$n(HC\ell)_{reacted} = 0,078\ mol$

Use of 0,06 dm^3

$HC\ell : CH_3OH$
1 : 1
$n(CH_3OH)_{reacted} = 0,078\ mol$

$$c(CH_3OH)_{remaining} = \frac{n}{V}$$

$$c(CH_3OH)_{remaining} = \frac{8,35 \times 10^{-2} - 0,078}{0,06}$$

$c(CH_3OH)_{remaining} = 0,092\ mol.dm^{-3}$ *(3 decimal places)*

QUESTION 4

4.1 A weak force of attraction between molecules, ions or atoms of noble gasses.

4.2
- As O_2 molecules approach each other
- there is a dispersion of electrons in each O_2 molecule
- resulting in instantaneous / induced dipoles forming
- which are then able to attract each other

OR
- As electrons of a molecule are constantly moving, they can be unequally distributed
- resulting in instantaneous dipole
- which can induce a dipole in a molecule nearby
- which are then able to attract each other

4.3
- Dipole-dipole forces between NO molecules
- are weaker than hydrogen bonding between NH_3 molecules
- thus, requiring less energy to overcome the forces.

OR
- hydrogen bonding between NH_3 molecules
- are stronger than dipole-dipole forces between NO molecules
- thus, requiring more energy to overcome the forces.

4.4 Exothermic
$\Delta H < 0$ **OR** more energy is released than absorbed

4.5 When an external stress is applied to a system in dynamic chemical equilibrium the equilibrium **point** will change in such a way to counteract the stress.

4.6
- Decrease pressure
- Response: Forward reaction favoured.
- Reasons: Forward reaction produces more moles of gas
- counteracting the stress / increasing the pressure.

Independent mark

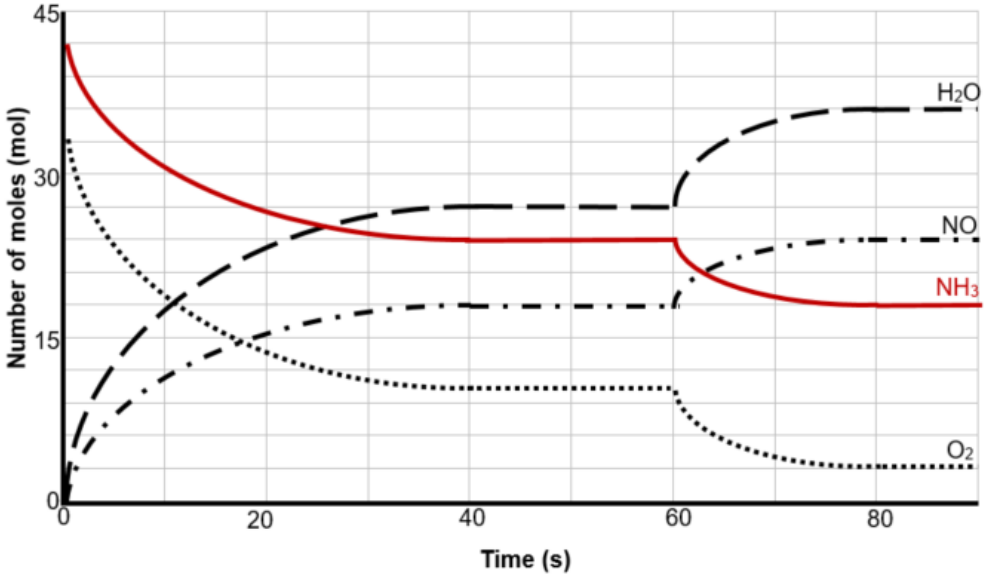
4.7 4.7.1 40 s (Award mark if they say 40-60s)

4.7.2 FORWARD

4.7.3 Yield of products increased / moles of reactants decreased.

- Forward reaction is exothermic/produces heat energy (counteracting the stress).
- Temperature decreased

4.7.4



- Shape 0–40 s & Shape 60–80 s
- Shape 40–60 s & Shape 80–90 s
- Starting value 42 mol,
- Equilibrium value 40–60 s 24 mol & equilibrium value 80-90 s 18 mol

4.7.5 $K_c = \frac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5}$

4.7.6 **POSITIVE MARKING FROM QUESTIONS 4.7.4 AND 4.7.5**

$$K_c = \frac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5} \quad K_c = \frac{\left[\frac{24}{20}\right]^4\left[\frac{36}{20}\right]^6}{\left[\frac{18}{20}\right]^4\left[\frac{3}{20}\right]^5} \quad [(\div 20)]$$

$$K_c = \frac{[1,2]^4[1,8]^6}{[0,9]^4[0,15]^5}$$

$$K_c = 1,42 \times 10^6$$

QUESTION 5

5.1 5.1.1 It is a measure of the hydronium ion concentration in water at 25 °C / 298 K.

5.1.2 Acid pH < 7 / lower than 7 / between 0-7 / starts at 3

5.1.3 **POSITIVE MARKING FROM QUESTION 5.1.2**
The volume of base added (cm^3) / Time (s)

5.1.4 Phenolphthalein
A strong base added to a weak acid / The equivalence point is above 7/around 10,2/between 8 and 10.

5.2 5.2.1 $K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$
$[H_3O^+](1,2 \times 10^{-10}) = 1 \times 10^{-14}$
$[H_3O^+] = 8,33 \times 10^{-5}$ mol.dm^{-3}

5.2.2 $[H_2SO_4] = ½[H_3O^+]$
$[H_2SO_4] = ½(8,33 \times 10^{-5})$
$[H_2SO_4] = 4,17 \times 10^{-5}$ mol.dm^{-3}

5.2.3 $H_2SO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + 2H_2O$
Reactants Products Balancing (only if the rest is correct)

5.2.4
- Acidic
- It is a reaction between a strong acid and a weak base.
- $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$
- The concentration of H_3O^+ increases / more H_3O^+ forms / H_3O^+ forms.

QUESTION 6

6.1 6.1.1 The electrode where oxidation takes place.

6.1.2
- Temperature of 25 °C or 298 K
- Concentration of solutions of 1 mol.dm^{-3}
- Pressure of gases of 1 atm / 101,3 kPa

6.1.3 (a) - +

(b) Ag

(c) Cathode

(d) $NaNO_3$ / KNO_3 / $LiNO_3$ (must have metal ion above Ag^+)

6.1.4 Pt(s) | H_2(g) | H^+(aq) ||

-1 for every other mistake
Penalise only once for phase indicators

6.1.5 Positive ions flow to the metal half-cell/cathode and negative ions flow to the SHE/anode.

6.1.6 (a) Increases the rate of reaction

(b) Increases the current

(c) No effect on emf

6.2 6.2.1 A substance that can conduct electricity by forming (free) ions when molten or dissolved in solution.

6.2.2
- Na^+ is too weak as an oxidising agent
- NO_3^- will not react as no H^+ present **OR**
- the concentration of H^+ is too low

OR
- $NaNO_3$ or Na^+ or NO_3^- forms/is (a) spectator ion(s) (1/2 only)

6.2.3 (a) $Pb \rightarrow Pb^{2+} + 2e^-$

(b) Cu^{2+} (must be formula)

6.2.4 $E^{\ominus}_{cell} = E^{\ominus}_{cathode} - E^{\ominus}_{anode}$
$E^{\ominus}_{cell} = 0,34 - (-0,13)$
$E^{\ominus}_{cell} = 0,47$ V

NO POSITIVE MARKING FROM Q. 6.2.3

QUESTION 7

7.1 7.1.1 $CuCl_2$(s) does not conduct electricity as it has no free ions (due to its fixed ionic lattice)
OR
$CuCl_2$(aq) does conduct electricity as there are free ions present (due to the dissociation of the ionic lattice).

7.1.2 Anode

7.1.3
- Ensures a high/constant concentration of chloride ions
- as the electrode potential for oxidation of H_2O is lower
- oxidation of H_2O will take place more readily

7.1.4 <u>OPTION 1</u>
Cu : e^-
1 : 2
$n(e^-) = 2(0,11) = 0,22$ mol

$q = nF$
$q = (0,22)(96500)$ use of 96500
$q = 21230$ C

<u>OPTION 2</u>
Cu : e^-
1 : 2
$n(e^-) = 2(0,11) = 0,22$ mol

$N(e^-) = nN_A = 0{,}22(6{,}02 \times 10^{23})$
$= 1{,}3244 \times 10^{23}$

$Q = N(e^-)q_e = (1{,}3244 \times 10^{23})(1{,}6 \times 10^{-19})$
$Q = 21\ 190{,}4$ C

7.1.5 $Cu : Cl^-$
1 : 2
$n(Cl^-) = 2(0{,}11) = 0{,}22$ mol

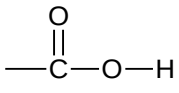
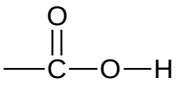
$N = nN_A$
$N = (0{,}22)(6{,}02 \times 10^{23})$ use of 6.02×10^{23}
$N = 1{,}32 \times 10^{23}$ ions

7.2 7.2.1 Becomes smaller / corrodes

7.2.2 $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

QUESTION 8

8.1 A functional group is an atom/a group of atoms that form the centre of chemical activity in the molecule.

8.2  ACCEPT: R  Nothing else accepted.

8.3 A compound in which there is at least one double and/or triple bond between carbon atoms.

8.4 Alkanes

8.5 Esters

8.6 8.6.1 Butan-1-ol & ethanoic acid

8.6.2
- Use a water bath
- Alcohols and/or carboxylic acids are flammable [Not explosive]

8.6.3 sulfuric acid [Must be the name]

8.6.4 Acts as a catalyst and a dehydrating agent.

8.6.5 H_2O [Must be the molecular formula]

QUESTION 9

9.1 General: Elimination
Specific: Cracking

9.2 $2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O$
Reactants Products Balancing (only if rest is correct)

9.3 9.3.1 Compounds with the same molecular formula but different structural formulae.

9.3.2 Chain isomerism

9.3.3 $CH_3CH(CH_3)CH_2CH_2CH3$
OR
$CH_3CH_2CH(CH_3)CH_2CH_3$
OR
$CH_3CH(CH_3)CH(CH_3)CH_3$

9.4 But-1-ene Accept: But-2-ene / butene

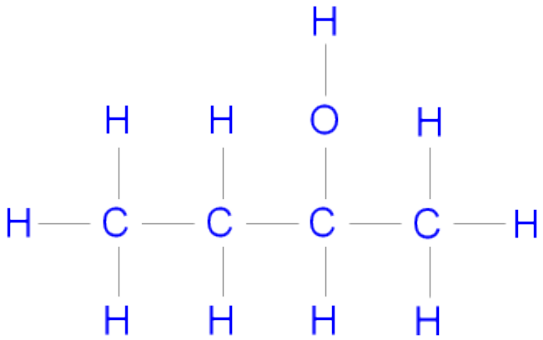
9.5 9.5.1 Hydrohalogenation

9.5.2 Absence of water

9.6 9.6.1 Substitution

9.6.2

- 4 Cs .
- Position of –OH
- Rest of molecule



9.6.3 iv – NaOH or KOH or LiOH Accept: A base / metal hydroxide
v – NaCl or KCl or LiCl Accept: A metal chloride

9.6.4 Dilute NaOH/KOH/LiOH/base
Heat (under reflux)

9.7 9.7.1 L < M < N **OR** L, M, N

9.7.2 **NO POSITIVE MARKING FROM Q. 9.7.1**

- Dipole-dipole forces in M
- are stronger than the London forces in L
- but weaker than the hydrogen bonding in N

TOTAL: 200 marks