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

QUESTION 2

2.1 2.1.1 An unequal sharing of electrons leading to a dipole forming (as a result of a difference in electronegativity)

2.1.2 H-C

2.1.3 smallest difference in electronegativity

2.2 2.2.1 H must be bonded to: A small atom
With high electronegativity
And at least one lone pair of electrons

2.2.2 The -O-H bond is very polar/strong dipole forms/H-nucleus is exposed/ higher charge density on the hydrogen/δ^+ and δ^- are big (due to large difference in electronegativity)
The molecules can get close together/the forces act over shorter distances (due to small atom)

2.3 physical intermolecular forces are overcome

2.4 Water forms 4 H-bonds with neighbouring molecules.
The other two compounds form 2 hydrogen bonds with neighbouring molecules.
More energy is needed to overcome the greater number of H-bonds/the stronger IMFs in water (and hence to separate water molecules.)

2.5 2.5.1 London/dispersion/induced dipole (forces)

2.5.2 ACCEPT **TWO** OF:
Ethanol has a larger electron cloud/more electrons
Ethanol has a larger interacting (contact) surface/longer chain than methanol
Ethanol forms larger/more temporary dipoles

QUESTION 3

3.1 3.1.1 $n(Cu) = \frac{m}{M} = \frac{2,54}{63,5}$ = **0,04 mol**

3.1.2 $n(HNO_3) = cV = 0,1 \times 0,8 =$ **0,08 mol**

3.1.3 0,08 mol HNO_3 reacts with $0,08 \times \frac{3}{8}$ = 0,03 mol Cu < 0,04 mol

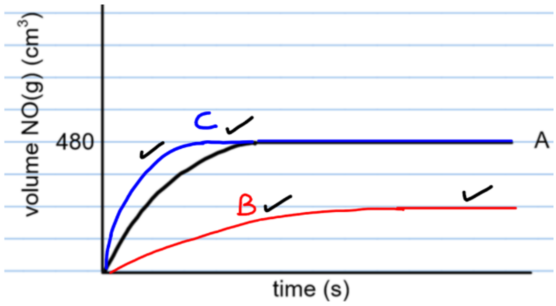
OR: 0,04 mol Cu needs $0,04 \times \frac{8}{3}$ = 0,107 mol HNO_3 > 0,08 mol

3.1.4 **0,08 mol HNO_3** (LR) produces $\frac{0,08}{4}$ = 0,02 mol NO

Carry over error from 3.1.2 (must use given LR i.e. HNO_3)

$V(NO) = nV_m = 0,02 \times 22,4 =$ **0,448 dm³**

3.2



B: half volume of A
Gradient less steep

C: same final volume as A
Steeper gradient than A

3.3 More particles per unit volume
∴ more collisions (per unit time)
∴ more effective collisions per unit time
∴ rate will increase

3.4 3.4.1 pH will INCREASE.
The concentration of acid / HNO_3 / H_3O^+ / H^+ is **decreasing** as the reaction proceeds.

3.4.2 % transmission will DECREASE.
(The concentration of $Cu(NO_3)_2$ is increasing),
so the solution becomes **darker blue**
so less light can pass through

3.5 3.5.1 A reaction that involves the transfer of electrons

3.5.2 Cu or copper

3.5.3 $NO_3^- + 4 H^+ + 3e^- \rightarrow NO + 2 H_2O$
(–1 for double arrow)

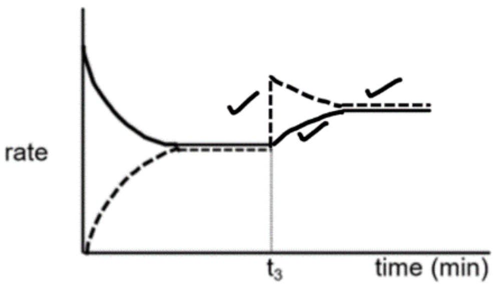
QUESTION 4

4.1 4.1.1 higher than

4.1.2 equal to

4.2 (The mole ratio shows that) for each mole of N_2O_4 that reacts, two moles of NO_2 are produced

4.3



Rate of reverse (only) increases at t_3
Rate of forward increases and reverse decreases
Equilibrium re-established (rates equal and higher than before)
–1 if both rates increase together at t_3

4.4 4.4.1 Both concentrations would sharply decrease at t_4

4.4.2 since c = n / V If V increases, c must decrease

4.5 in order to decrease the temperature/absorb heat/relieve the stress
the forward reaction is favoured
because it is endothermic (and absorbs heat)
thus the $[NO_2]$ increases and the $[N_2O_4]$ decreases

4.6 The concentrations remain constant/There is no effect.
Because:
the rate at which N_2O_4 produces NO_2 and the rate at which NO_2 forms N_2O_4 increase by the same amount
OR the rates of both (the forward and reverse) reactions increase equally/ by the same amount

4.7 4.7.1 $K_c = \frac{[NO_2]^2}{[N_2O_4]}$

4.7.2 $N_2O_4 \rightleftarrows 2\,NO_2$

	N_2O_4	$2\,NO_2$
Initial	0,46	0
Change	– 0,095	+ 0,19
Equilibrium	0,365	0,19

$K_c = \frac{[0{,}19]^2}{[0{,}365]}$ coe = **0,099** OR 0,10

QUESTION 5

5.1 5.1.1 proton donor

5.1.2 sulfurous acid (accept sulphurous acid)

5.1.3 an acid that only ionizes partially in an aqueous solution

5.1.4 H_3O^+ or H^+ concentration OR $[H_3O^+]$ OR $[H^+]$

5.1.5 A

5.1.6 EITHER: **B** (H_2SO_4) is the **strongest** acid solution.
OR: **C** is the **most concentrated** acid solution.

5.2 5.2.1 amphiprotic OR amphoteric OR ampholyte

5.2.2 $H_2PO_4^- + HCO_3^- \rightleftharpoons H_3PO_4 + CO_3^{2-}$

Base	Acid	Acid	Base

pairs are correct labels are correct

5.3 5.3.1 $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$

5.3.2 $F^- + H_2O \rightleftharpoons HF + OH^-$
(–1 if no reversible arrows – penalise once only)

5.3.3 (a) acidic

(b) K_a for NH_4^+

(c) NH_4^+ ionises more than F^-
$[H_3O^+] > [OH^-]$

5.4 5.4.1 $Na_2CO_3 + 2HBr \rightarrow 2NaBr + CO_2 + H_2O$
products balancing

5.4.2 $n(Na_2CO_3) = cV = 0,12 \times 0,02 = 0,0024$ mol
$n(HBr) = \mathbf{2 \times} 0,0024 = 0,0048$ mol (2:1) **indicate** ratio used (coe from 5.4.1)
$c(HBr) = n / V = 0,0048 / 0,0152 = 0,3158$ mol.dm^{-3}✓ (4 d.p.)

OR USE: $\frac{c_aV_a}{a} = \frac{c_bV_b}{b}$ or other version thereof

$\frac{c_a \times 0,0152}{2} = \frac{0,12 \times 0,0200}{1}$ ratio indicated
(coe from 5.4.1)
$c(HBr) = 0,3158$ mol.dm^{-3} (4 d.p.)

QUESTION 6

6.1 The gauze provides a bigger surface area
EITHER:
It is a better catalyst for the reaction (since electron transfer takes place on its surface).
It increases the rate of the reaction more (vs a wire)
It increases the current the cell can deliver more than the wire does.

6.2 Sn^{4+}

6.3 $Cr | Cr^{3+} || Sn^{4+}, Sn^{2+} | Pt$

	Correct anode
	Correct cathode
–1 in total for any punctuation errors	Salt bridge
e.g. | instead of ,	Platinum

6.4 6.4.1 tin(IV) chloride (accept tin tetrachloride or stannic chloride)

6.4.2 $C\ell^-$ (or chloride)

6.4.3 (anions from the cathode electrolyte move into the anode electrolyte) to balance the extra positive charge resulting from the oxidation of Cr to Cr^{3+}
OR: (anions move out of the cathode electrolyte) due to an increase of negative charge there resulting from reduction of Sn^{4+} to Sn^{2+}

6.5 TWO OF:
Use a shorter salt bridge
Use a wider salt bridge
Use more concentrated KNO_3 solution
Use a more conductive salt in the salt bridge

6.6 m = cVM = 0,5 × 0,25 × 392 = **49 g**
OR n = cV = 0,5 × 0,25 = 0,125 mol
m = nM = 0,125 × 392 = 49 g one mark for both equations

6.7 6.7.1 metallic bonding

6.7.2 it can conduct electricity because the (delocalised) electrons are **free to move/mobile**

QUESTION 7

7.1 7.1.1 it is inert

7.1.2 positive

7.1.3 reduction
EITHER: electrons are gained
OR: the oxidation number of H decreases
OR: it takes place at the cathode

7.1.4 $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode} = -0,83 - 1,23 = \mathbf{-2,06\ V}$
no carry-over

7.1.5 non-spontaneous; $E^{\theta}_{cell} < 0$ (must follow from 7.1.4)

7.1.6 (a) blue

(b) blue

7.1.7 (a) q = It = 0,05 × (1,5 × 3 600) = **270 C**

(b) $n(e^-) = \frac{q}{F} = \frac{270(coe)}{96500}$ = 0,0028 mol ÷ 96 500

[**OR** $N(e^-) = 270 / 1,6 \times 10^{-19}$ Then $n(e^-) = N / N_A$ = 0,0028 mol]

$n(O_2) = \frac{0,0028}{4}$ = 0,0007 mol ÷ 4

$V(O_2) = nV_m$ = 0,0007 × 22,4 × 22,4

= 0,016 dm^3 **OR** 0,02 dm^3

7.2 7.2.1 brine

7.2.2 mercury cell.
NaOH produced in separate vessel/area.

7.2.3 diaphragm cell
Contaminant is NaCℓ
because diaphragm allows anions/$C\ell^-$/all ions through (non-selective).

QUESTION 8

8.1 1-bromo propane

8.2 haloalkane

8.3 8.3.1 $CH_3CH{=}CH_2$ (–1 if molecular formula given C_3H_6)

8.3.2 $CH_3CH_2CH_2OH$ propanol -OH on C_1
(–1 if molecular formula given C_3H_8O or C_3H_7OH)

(–1 in total if structural formula used in 8.3)

8.4 Elimination

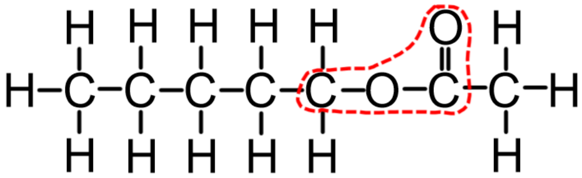
8.5 Hydrolysis

8.6 Dehydration

8.7 The organic compounds may have low boiling points and escape from the reaction vessel.

QUESTION 9

9.1 9.1.1



Correct functional group
Correct pentyl
Correct ethanoate
Condensed formula (–1)
Missing H's (–1)

9.1.2 ester group (COOC) circled (accept COO – as in SAGS)

9.1.3 condensation

9.1.4 ethanoic acid

9.2 heptan**e**-3,3-diol correct chain length diol correct correct numbering
mistakes in format or **e** or **ane** omitted (–1)

9.3 9.3.1 (thermal) cracking

9.3.2 prop ene

9.4 9.4.1 Butane: (red-brown) colour remains /(red-brown) colour fades slowly /nothing happens

But-1-ene: (red-brown) colour disappears quickly / immediately

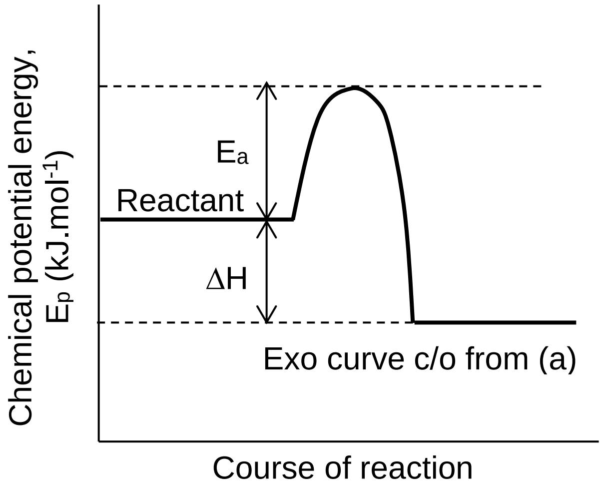
Colour disappears faster for but-1-ene than for butane
1 mark for colour disappearing
2 marks for relative rate of disappearance

9.4.2 substitution

9.4.3 $CH_3CH_2CHCH_2 + Br_2 \rightarrow CH_3CH_2CHBrCH_2Br$
–1 if structural formulae used

9.4.4 (a) $\Delta H = E_a - E_{out} = 4\ 795 - 4\ 889 = -94\ kJ.mol^{-1}$

(b&c)



Max 1/3 if (a) correct but endo curve drawn.
Max 2/3 if (a) incorrect and endo curve drawn.

Total: 200 marks