NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 2021

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 B
1.5 D
1.6 A
1.7 C
1.8 C
1.9 C
1.10 D

QUESTION 2

2.1 2.1.1 A bond between a **positive kernel** and a **sea of delocalised electrons**.

2.1.2 (a) Solid

(b) Liquid

2.1.3 X
It conducts due to the presence of free/mobile (valence) electrons in both the solid and liquid phases.

2.1.4
- Y has ionic bonding
- which has ions in fixed positions in a solid crystal lattice
- In liquid phase, the ions are free to move and thus conduct electricity

2.2 2.2.1 A **weak force of attraction** between **molecules, ions, or atoms of noble gases**.

2.2.2
- Both IBr and IF have dipole-dipole interactions and London forces
- (Although IF is a more polar molecule and thus has stronger dipole-dipole interactions,) the London forces in IBr are much stronger than those in IF
- This is due to the greater electron density (OR higher number of electrons) in IBr
- leading to larger (and longer-lasting) induced dipoles
- Thus, more energy is required to overcome the intermolecular forces OR separate the particles in IBr
- (Resulting in IBr having a higher melting point)

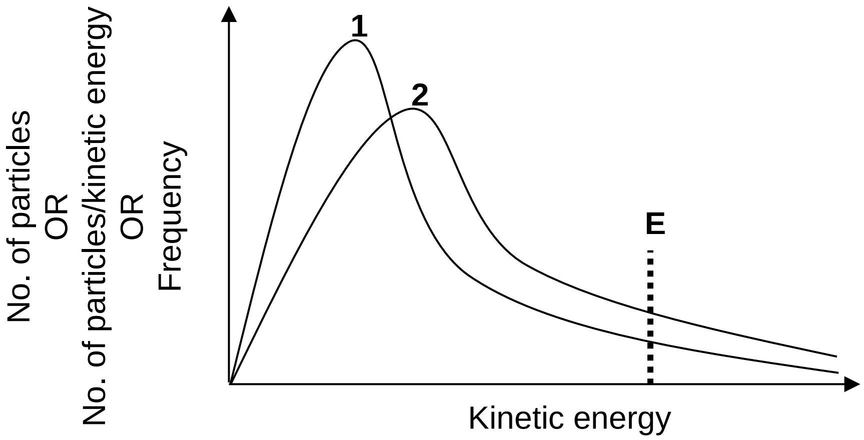
QUESTION 3

3.1 $HC\ell + H_2O \rightarrow C\ell^- + H_3O^+$
LHS
RHS
Single arrow

3.2 S

3.3 4

3.4 3.4.1



Correctly labelled *y*-axis
Experiment 2 peak lower than experiment 1 peak
Experiment 2 peak at higher kinetic energy than experiment 1 peak
Activation energy correctly placed and same for both experiments

3.4.2
- An increase in temperature causes the average kinetic energy of the particles to increase
- From the Maxwell-Boltzmann distribution curve, we can see that there is an increase in the proportion of particles with sufficient kinetic energy (to overcome the activation energy)
- This (together with the increase in speed and therefore number of collisions per unit time) results in a greater number of effective collisions per unit time
- Therefore, Experiment 2 has a higher reaction rate

3.5 3.5.1 B c.o.e from Q3.3 – if 2 has been identified as faster, then A.

3.5.2 A c.o.e from Q3.3 – if 2 has been identified as faster, then B.

3.5.3 C

3.6 3.6.1 The minimum energy required to start a chemical reaction
OR the energy required to form the activated complex

3.6.2 Exothermic

3.6.3 Negative

3.6.4 Products

3.6.5 Addition of a suitable catalyst

QUESTION 4

4.1 That there is a much larger amount of reactants than products (OR the reactants are favoured)

4.2
- Internal combustion engines have extremely high temperatures
- Le Châtelier's principle predicts the system will respond in order to decrease the temperature
- Thus, the forward reaction is (initially) favoured as it is endothermic and thus consumes heat
- increasing the amount of nitrogen monoxide

OR
- Internal combustion engines have extremely high temperatures
- This increases both the forward and reverse reaction rates
- This forward reaction rate increases more as it is endothermic
- Thus, the forward reaction is (initially) favoured
- increasing the amount of nitrogen monoxide
  [NO marks awarded for an explanation of pressure]

4.3 Remains the same

4.4 Increase

4.5 4.5.1 $K_c = \frac{[NO]^2}{[N_2][O_2]}$

4.5.2 *Moles:*

R	N_2	+	O_2	⇌	2NO
I	$4,5\times10^{-3}$		$4,5\times10^{-3}$		0
C	$(-x$		$-x)$		$+2x$
E	$4,5\times10^{-3}-x$		$4,5\times10^{-3}-x$		$2x$
[ ]	$\frac{4,5\times10^{-3}-x}{0,2}$		$\frac{4,5\times10^{-3}-x}{0,2}$		$\frac{2x}{0,2}$

$$K_c = \frac{[NO]^2}{[N_2][O_2]}$$

$$\left(1,1\times10^{-5}\right) = \frac{\left(\frac{2x}{0,2}\right)^2}{\left(\frac{4,5\times10^{-3}-x}{0,2}\right)\left(\frac{4,5\times10^{-3}-x}{0,2}\right)}$$

$$x = 7,45\times10^{-6}$$

$$[\mathbf{NO}] = 3,73\times10^{-5}\ \mathbf{mol{\cdot}dm^{-3}}$$

OR

Concentration:

R	N_2	+	O_2	$\rightleftharpoons$	$2NO_2$
I	0,0225		0,0225		0
C	$(-x$		$-x)$		$+2x$
E	$0{,}0225-x$		$0{,}0225-x$		$2x$

$$K_c = \frac{[NO_2]^2}{[N_2][O_2]}$$

$$(1{,}1\times10^{-5}) = \frac{(2x)^2}{(0{,}0225-x)(0{,}0225-x)}$$

$$x = [NO_2] = 3{,}73\times10^{-5}\ \text{mol}\cdot\text{dm}^{-3}$$

4.6 $2NO + O_2 \rightleftharpoons 2NO_2$
LHS and RHS
Balancing
Reversible arrow

4.7
- Stress: decrease in pressure
- Le Châtelier's principle predicts the system will respond in order to increase the pressure
- Thus, the reverse reaction is (initially) favoured as it produces more gas particles
- decreasing the amount of NO_2
- causing the brown colour to fade

[Allow carry-over from Question 4.6 if different mole ratio is used]

QUESTION 5

5.1 A proton donor.

5.2 5.2.1 A substance that can act as either an acid or a base.

5.2.2 HSO_3^-

5.2.3 H_2SO_3

5.3 5.3.1 Yellow

5.3.2 Bromothymol blue

5.4 5.4.1 A reaction of an ion (from a salt) with water.

5.4.2
- $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$ (OR $NH_4^+ + H_2O \rightleftharpoons NH_4OH + H^+$)
- The ammonium ion hydrolyses water
- because it is the conjugate acid of the weak base NH_3
- resulting in an excess of hydronium (OR hydrogen) ions
- and an acidic solution

[Only 1 mark for saying $NH_4C\ell$ is the salt of a strong acid and weak base.]

5.5 5.5.1 $n = cV$

$n = (1,2)(0,2)$

$\boldsymbol{n} = 0,24$ **mol**

5.5.2 A solution of known concentration.

5.5.3 The point where an acid and base have reacted so neither is in excess.

5.5.4 $2HNO_3 + Na_2CO_3 \rightarrow 2NaNO_3 + CO_2 + H_2O$

- $n_{Na_2CO_3}(titrated) = cV$
- $n_{Na_2CO_3}(titrated) = (0{,}85)(0{,}02367) = 0{,}0201195$ mol
- $n_{HNO_3}(titrated) = n_{HNO_3}(excess) = (0{,}0201195) \times \frac{2}{1} = 0{,}040239$ mol in 50 cm^3
- Therefore (4 × 0,040239 mol) = 0,160956 mol in 200 cm^3
- $n_{HNO_3}(neutralised\ by\ KOH) = (0{,}24) - (0{,}160956) = 0{,}079044$ mol
- $m_{KOH}(neutralised\ by\ HNO_3) = nM$
- $m_{KOH}(neutralised\ by\ HNO_3) = (0{,}079044)(56) = 4{,}426464$ g
- $\%\,purity = \frac{pure\ mass}{impure\ mass} \times 100$
- $\%\,purity = \frac{(4{,}426464)}{(13)} \times 100$
- $\%\,purity = 34{,}05\%$

QUESTION 6

6.1 Galvanic

6.2 $Cr_2(SO_4)_3$

6.3 6.3.1 The gain of electrons.

6.3.2 $Cu^{2+} + 2e^- \rightarrow Cu$

6.3.3 The electrode at which oxidation takes place.

6.3.4 Cr OR chromium

6.3.5
- The chromium anode will corrode (OR lose mass OR disintegrate)
- The green colour of the electrolyte will intensify (OR darken)

6.4 $3Cu^{2+} + 2Cr \rightarrow 3Cu + 2Cr^{3+}$
LHS
RHS
Balancing

6.5 6.5.1
$$E^0_{cell} = E^0_{cathode} - E^0_{anode}$$
$$E^0_{cell} = (+0,34) - (-0,74)$$
$$E^0_{cell} = 1,08\ \mathbf{V}$$

6.5.2
- Stress: an increase in the concentration of Cu^{2+}
- Le Châtelier's principle predicts the system will respond in order to decrease the concentration of Cu^{2+}
- This would result in the forward reaction being (initially) favoured as the forward reaction consumes Cu^{2+}
- Causing the initial emf to increase

6.6 6.6.1 KNO_3

6.6.2
- Cr^{3+} ions are being produced (OR the concentration of Cr^{3+} ions is increasing)
- This causes anions (e.g. NO_3^- ions) migrating out of the salt bridge into the electrolyte
- and cations (Cr^{3+} ions) migrating into the salt bridge out of the electrolyte

6.7 $Cr(s)\ |\ Cr^{3+}(aq,\ 1\ mol{\cdot}dm^{-3})\ ||\ Cu^{2+}(aq,\ 1\ mol{\cdot}dm^{-3})\ |\ Cu(s)$ at 25 °C
Oxidation half-cell
Reduction half-cell
Salt bridge
Phase indicators
Conditions

QUESTION 7

7.1 Brine

7.2 A substance that can conduct electricity by forming **free ions** when molten or dissolved in solution.

7.3 $2C\ell^- \rightarrow C\ell_2 + 2e^-$

7.4 Chlorine

7.5
- No
- The very low concentration of $C\ell^-$ ions significantly slows down the rate of its oxidation
- Resulting in the H_2O becoming oxidised predominantly (forming O_2)

7.6 $Na^+ + e^- + Hg \rightarrow Na\text{-}Hg$ (OR Na/Hg)
[1 mark only for $Na^+ + e^- \rightarrow Na$]

7.7 It is pumped to a separate reactor (sodium digester) where it is reacted with water forming NaOH and H_2.

7.8
- Copper is a much stronger reducing agent than both $C\ell^-$ and H_2O
- Therefore, it is much more likely to be oxidised than either of these species (resulting in copper being oxidised instead of the $C\ell^-$)

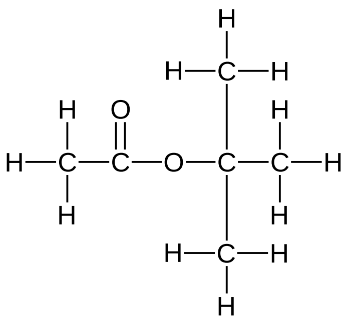
7.9
- The mercury cell uses mercury which is very toxic (whereas the membrane cell does not use any toxic materials only)
- The mercury cell is more expensive to run
- given the higher electricity demands for the electrolysis

QUESTION 8

8.1 5−methylheptane−2,5−diol
5−methyl
hept
ane
2,5−diol

8.2 2−methylpent−1−ene
2−methyl
pent
1−ene

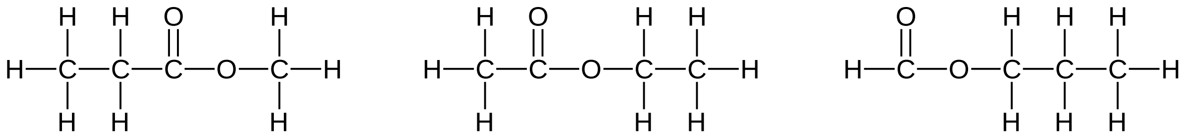
8.3



8.4 An atom or a group of atoms that form the centre of chemical activity in the molecule

8.5 Carboxyl group

8.6 One of the following:



4 carbons
ester

QUESTION 9

9.1 9.1.1 Addition

9.1.2 Substitution

9.1.3 Elimination

9.2 9.2.1 Halogenation (OR bromination)

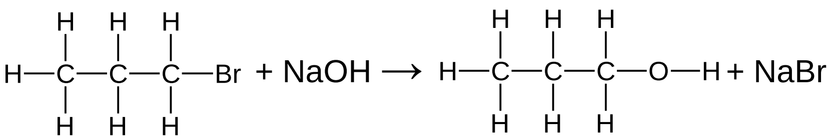
9.2.2 Hydrohalogenation

9.2.3 Hydrolysis

9.2.4 Dehydrohalogenation

9.3 Alkanes

9.4 $CH_3CHCH_2 + HBr \rightarrow CH_3CH_2CH_2Br$
OR
$CH_3—CH═CH_2 + HBr \rightarrow CH_3—CH_2—CH_2—Br$

9.5


Haloalkane structure
NaOH
Alcohol structure
NaBr

9.6 Propene (OR prop−1−ene)

Total: 200 marks