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

QUESTION 2

2.1 2.1.1 The net change of chemical potential energy of the system.

2.1.2 A reaction which transforms thermal energy into chemical potential energy.

2.1.3 Exothermic

2.1.4 Endothermic

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

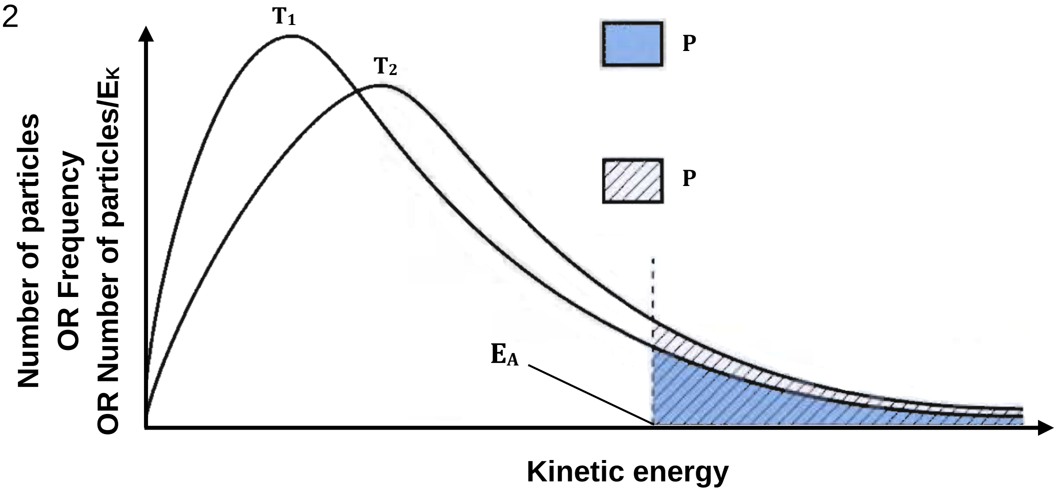
2.2.2 London (OR dispersion OR induced dipole) forces

2.2.3
- The weak London forces
- require little energy to be overcome OR little energy is needed to separate the particles

Do NOT accept: break bonds

2.3 2.3.1 The change in concentration per unit time (second: NOT "over time") (OR rate of change in concentration) of either a reactant or a product.

2.3.2



- Y-axis correct (Accept: faction of particles, % particles, amount (moles) of particles; molecules instead of particles.)
- Shape of higher-temperature graph: peak must be to the right and below the peak of the lower-temperature graph AND stays above the original graph
- Activation energy indicated
- Proportion of particles indicated

2.3.3
- An increase in temperature means that the (average) kinetic energy of the particles increases
- (From the Maxwell-Boltzmann distribution curve, we can see that) there is a greater proportion of particles with kinetic energy greater than activation energy OR area P increases
- thus, there is a greater number of effective collisions occurring per second (accept: frequency/chance of effective collisions)
- leading to a higher reaction rate

2.3.4
- Relevant equipment, e.g. gas syringe OR water-filled inverted measuring cylinder in a water-filled trough OR electronic balance/scale OR pressure sensor OR pHM meter
- Relevant amount/quantity, e.g. volume (of ethane) OR mass (of ethane) OR mass (of flask and its contents) OR pressure (of ethane gas) OR pH
- Time

2.4 2.4.1 $n(\text{DEZ}) = \frac{m}{M} = \frac{(50)}{(123,4)} = 0,4052 \text{ mol}$

$n(H_2O) = \frac{m}{M} = \frac{(40)}{(18)} = 2,2222 \text{ mol}$

(There is a 1:1 ratio, so the substance that there is the least amount of is the limiting reagent)

Therefore, the **diethyl zinc** is the limiting reagent

OR

123 g DEZ reacts with 18 g H_2O

50 g DEZ reacts with 7,29 g H_2O

Therefore, the **diethyl zinc** is the limiting reagent

2.4.2 This question is linked to Q 2.4.1
- $n(\text{ethane}) = n(\text{DEZ}) = 0,4052$ mol (this mark may be implied)
- $V = nV_m$ = (0,4052)(22,4) = **9,08 dm³**

QUESTION 3

3.1 Exothermic

3.2
- From the graph, we can see that an increase in temperature decreases the yield of ammonia
- meaning an increase in temperature favours the reverse reaction
- According to Le Châtelier's principle, an increase in temperature will favour the reaction that decreases the temperature
- favouring the endothermic reaction as it consumes heat
- meaning the reverse reaction is endothermic
- thus, the forward reaction is exothermic

3.3 **16 %**
Accept 15,5 % – 16 %

3.4 Yes

3.5
- the lower yield would be produced at a higher rate
- therefore, more ammonia is produced per day (or other unit time) (more **total** NH_3 – 1 mark)

OR
- the higher yield would be produced at a lower rate
- therefore, less ammonia is produced per day (or other unit time) (less **total** NH_3 – 1 mark)

If they only say that "yield is sacrificed for rate" – 1 mark only

3.6 No effect

3.7
- No
- The equilibrium constant is temperature dependent
- The temperature that this equilibrium constant was measured at (472 °C) is not the same as the industrial temperature used (450 °C)

Accept yes ONLY if they link this to the industry temperature being adjusted to 472 °C. Any link to pressure being the reason will get no marks for the explanation (2nd and 3rd bullets)

3.8 One in which both energy and matter can be exchanged between the system and its surroundings

3.9
- Continuously removing the ammonia (OR product) (continuously) decreases the reverse reaction rate
- resulting in the forward reaction being favoured (OR faster) Accept: both rates decrease but the reverse rate decreases more.
- favouring the yield of ammonia

QUESTION 4

4.1 The amount of (moles) of **solute** per unit volume of **solution**.

4.2 $m = cMV$

m = (0,32)(74)(0,5) (substitution) (conversion of volume)

$\boldsymbol{m}$ **= 11,84 g**

OR

$n = cV$

n = (0,32)(0,5) (conversion of volume)

n = 0,16 mol

$m = nM$ (both equations)

m = (0,16)(74) (substitution)

$\boldsymbol{m}$ **= 11,84 g**

4.3 It ionises partially (in solution) (OR it has a low K_a / K_c OR lower concentration of products than reactants)

4.4 $K_a = \frac{[CH_3CH_2COO^-][H_3O^+]}{[CH_3CH_2COOH]}$

4.5 *Concentrations:*

Reaction	CH_3CH_2COOH	+	H_2O	⇌	$CH_3CH_2COO^-$	+	H_3O^+
Initial	0,32				0		0
Change	$-x$				x		x
Equilibrium	$0,32 - x$				x		x

[Ignore any values in the H_2O column]

$$K_a = \frac{[CH_3CH_2COO^-][H_3O^+]}{[CH_3CH_2COOH]}$$

$(1,34 \times 10^{-5}) = \frac{(x)(x)}{(0,32-x)}$ (top) (bottom) (both substitution of concentrations)

$\boldsymbol{[H_3O^+] = x = 2,06 \times 10^{-3}\ mol{\cdot}dm^{-3}}$

OR

Moles:

Reaction	CH_3CH_2COOH	+	H_2O	⇌	$CH_3CH_2COO^-$	+	H_3O^+
Initial	0,16				0		0
Change	$-x$				$(x$		$x)$
Equilibrium	$0,16 - x$				x		x
Conc	$0,32 - 2x$				$2x$		$2x$

[Ignore any values in the H_2O column]

$$K_a = \frac{[CH_3CH_2COO^-][H_3O^+]}{[CH_3CH_2COOH]}$$

$(1,34 \times 10^{-5}) = \frac{(2x)(2x)}{(0,32-x)}$ (top) (bottom) (both substitution of concentrations)

$\boldsymbol{[H_3O^+] = 2,06 \times 10^{-3}\ mol{\cdot}dm^{-3}}$

C.o.e. from Q 4.4 for a maximum of 3 out of 4 marks.
If not table is shown, then 2 marks may be awarded for the top of the fraction and 2 for the bottom.

4.6 $K_w = [H_3O^+][OH^-]$

$(1 \times 10^{-14}) = (2{,}06 \times 10^{-3})[OH^-]$

$\mathbf{[OH^-] = 4{,}85 \times 10^{-12}\ mol{\cdot}dm^{-3}}$

Accept calculation using pOH

$pH = -\log [h_3O^+]$
$pH = -\log [2{,}06 \times 10^{-3}]$
$pH = 2{,}69$

$\therefore pOH = 14 - 2{,}69 = 11{,}314$

$pOH = -\log [H_3O^+]$
$(11{,}315) = -\log [OH^-]$
$[OH^-] = 4{,}85 \times 10^{-12}\ mol.dm^{-3}$

4.7 A sharing of at least one pair of electrons by two non-metal atoms.

4.8 A measure of the tendency of an atom to attract a bonding (shared) pair of electrons.

4.9 Polar covalent bond

QUESTION 5

5.1 5.1.1 Step 2: the pipette was rinsed with water instead of the propanoic acid
OR
Step 3: the *bottom* of the meniscus was not on the mark

5.1.2 Step 2:
- This will decrease the concentration of the propanoic acid used
- a smaller volume of $Ba(OH)_2$ would be needed to neutralise the acid
- resulting in a **higher** than actual concentration of barium hydroxide

OR

Step 3:
- This will decrease the volume of propanoic acid used
- a smaller volume of $Ba(OH)_2$ would be needed to neutralise the acid
- resulting in a **higher** than actual concentration of barium hydroxide

5.2 5.2.1 The point where an acid and base have reacted so that neither is in excess.

5.2.2 $2CH_3CH_2COOH + Ba(OH)_2 \rightarrow (CH_3CH_2COO)_2Ba + 2H_2O$
balancing

5.2.3 ±9
Any basic pH – 1 mark only
a pH between 8 and 10 – both marks

5.2.4
- $n_a = c_aV_a = (0{,}32)(0{,}02) = 0{,}0064$ mol
- $n_b = n_a \times \frac{1}{2} = (0{,}0064) \times \frac{1}{2} = 0{,}0032$ mol (coe from Question 5.2.2)
- $c_b = \frac{n_b}{V_b} = \frac{(0{,}0032)}{(0{,}01894)} = \mathbf{0{,}17\ mol{\cdot}dm^{-3}}$

OR

$$\frac{n_b}{n_a} = \frac{c_bV_b}{c_aV_a}$$

$$\frac{1}{2} = \frac{c_b(0{,}01894)}{(0{,}32)(0{,}02)}$$

$c_b = \mathbf{0{,}17\ mol{\cdot}dm^{-3}}$

5.2.5 (a) Imprecise as the readings are not close to each other (OR not close to the average)
OR precise – readings are close to each other)

(b) Accurate as the concentration of $Ba(OH)_2$ calculated is close to the actual (true) concentration
OR inaccurate – the concentration of $Ba(OH)_2$ calculated is not close to the actual (true) concentration

QUESTION 6

6.1 6.1.1 (Pressure of) 1 atm (OR 101 kPa / 101,3 kPa / 1, 01 x 10^5 Pa)

6.1.2 (Concentration of) 1 $mol \cdot dm^{-3}$

6.1.3 Negative

6.1.4 $E^{2}_{cell} = E^{2}_{cathode} - E^{2}_{anode}$

$E^{2}_{cell} = (-0,25) - (0)$

$\mathbf{E^{2}_{cell} = -0,25\ V}$

Full marks only to be awarded if the calculation is shown (this value can be read directly off the table)

6.2 6.2.1 $2H^+ + 2e^- \rightarrow H_2$

6.2.2
- $Q = It = (2,25)(4 \times 3\ 600)$ (sub) (conv) = 32 400 C
- $n_{e^-} = \frac{Q}{F} = \frac{(32400)}{(96500)} = 0,33575\, mol$
- $n_{Ni} = \frac{1}{2} \times n_{e^-} = \frac{1}{2} \times (0,33575) = 0,1679\, mol$
- $m_{Ni} = nM = (0,1679)(59) = \mathbf{9,9\ g}$

6.2.3 <u>linked</u> to Question 6.2.1
- in the nickel half-cell cations (Ni^{2+}) are produced (OR concentration of Ni^{2+} increases OR there are excess cations)
- (in order to prevent the build-up of positive charge) anions from the salt bridge enter the half-cell
- and cations from the half-cell (Ni^{2+}) enter the salt bridge

6.3 6.3.1 Increase

6.3.2 No effect

QUESTION 7

7.1 Any impurities will decrease the conductivity (OR increase the resistance) of the copper.
[Accept: any impurities will *affect* the conductivity/resistance of the copper]

7.2 Electrical (potential) energy to chemical (potential) energy

7.3 7.3.1
- Dissolving the $CuSO_4$ in solution mobilises/frees the ions
- allowing the solution to conduct electricity (OR allows the ions to migrate to the electrodes)

7.3.2 It increases the conductivity of the electrolyte solution

7.4 Positive

7.5 7.5.1 Copper will deposit on the cathode (it will gain mass)

7.5.2 $Cu^{2+} + 2e^- \rightarrow Cu$ (–1 for whole question for use of $\rightleftharpoons$)

7.6 7.6.1 The loss of electrons.

7.6.2 $Cu \rightarrow Cu^{2+} + 2e^-$ (–1 for whole question for use of $\rightleftharpoons$)

7.6.3 Silver and gold

7.6.4
- Zinc is a stronger reducing agent (OR has a more negative electrode potential) than copper
(therefore, if copper is oxidised, so will zinc)
- however, silver is a much weaker reducing agent than copper
- (so it will not oxidise)

7.7
- Cu^{2+} ions are being produced at the anode and reduced (consumed) at the cathode
- however, for every other ion produced at the anode (Zn^{2+} and Co^{2+}), a Cu^{2+} ion is reduced at the cathode (OR only Cu^{2+})
- because more Cu^{2+} ions are consumed than produced (or more Cu^{2+} is reduced than Cu oxidised), the concentration of the Cu^{2+} will decrease

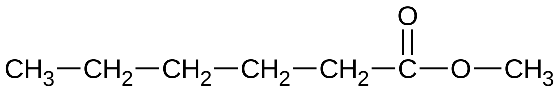
OR
- Cu^{2+}, Co^{2+} and Zn^{2+} ions are produced by oxidation at the anode
- ONLY Cu^{2+} ions are reduced at the cathode
- therefore, the concentration of the Cu^{2+} will decrease

QUESTION 8

8.1 8.1.1 An atom or a group of atoms that form the centre of chemical activity in the molecule.

8.1.2 Hydroxyl group

8.1.3



$CH_3-CH_2-CH_2-CH_2-CH_2-\overset{\overset{\displaystyle O}{||}}{C}-O-CH_3$

OR

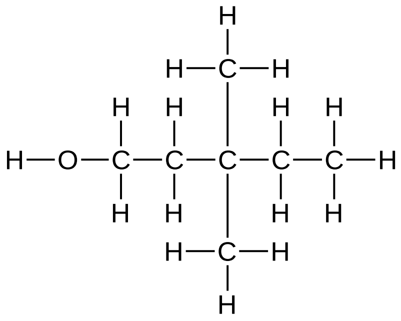
$CH_3CH_2CH_2CH_2CH_2COOCH_3$

OR

$CH_3(CH_2)_4COOCH_3$

7 carbon ester
Correct number of carbons on either side

8.1.4



5 carbon parent chain
Two methyl groups on carbon 3
Hydroxyl group on carbon 1

8.1.5 Compounds (OR molecules) having the same molecular formula but different structural formulae.

8.1.6 heptanoic acid
heptan
oic acid

8.2 8.2.1 4−ethylhexa−1,4−diene
4-ethyl
hex
a
1,4−diene

8.2.2 1,1−dibromo−2−chloropropane
1,1−dibromo
2−chloro
prop
ane

8.2.3 (a) A compound containing **only** carbon and hydrogen (atoms).

(b) Unsaturated)

QUESTION 9

9.1 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**.
[All four bolded parts are necessary – any missing part loses a mark)

9.2 Alkenes

9.3 Addition

9.4 Elimination

9.5 Dehydration

9.6 Hydrolysis

9.7 Ethanol
Eth
an
ol
Accept: ethan−1−ol

9.8 bromoethane
bromo (OR 1−bromo)
eth
ane

9.9
- Compound **B** has hydrogen bonds
- Compound **C** has London forces (and/or dipole-dipole interactions)
- the hydrogen bonds are stronger than the London forces
- more energy is needed to overcome the intermolecular forces (OR separate the particles) in compound **B**

Do NOT accept "break bonds"
- resulting in compound **B** having a higher boiling point

9.10 Esters

Total: 200 marks