NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2017

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 A

1.2 D

1.3 B

1.4 C

1.5 B

1.6 C

1.7 B

1.8 C

1.9 A

1.10 D

QUESTION 2 CHEMICAL BONDING

2.1 A covalent bond is a **sharing** of at least one pair of **electrons** by two (non-metal) atoms.

2.2 A non-polar covalent bond is an **EQUAL sharing of electrons**.
A polar covalent bond is an UNEQUAL sharing of electrons.

2.3

2.3.1 hydrogen OR chlorine

2.3.2 hydrogen chloride OR hydrogen fluoride

2.3.3 aluminium oxide

2.3.4 hydrogen fluoride

2.3.5 hydrogen chloride

2.3.6 argon

2.3.7 magnesium

2.3.8 graphite

QUESTION 3 ENERGY CHANGE

3.1.1 Activation energy is the **MINIMUM** energy required to start a chemical reaction.

3.1.2 A catalyst is a (chemical) **substance** that increases the rate of a chemical reaction but remains unchanged at the end of the reaction

3.2 E_A = (242,6 + 92,4) = **335 kJ·mol^{-1}** (-1 if no unit)

3.3 Error: There will NOT be more collisions taking place per second (per unit time).
The number of EFFECTIVE (successful) collisions (per second) increases (since more of the molecules will have the required activation energy).

3.4 **Platinum**. It **lowers the activation energy the most**, (has the lowest activation energy) which means that **more of the molecules will have the activation energy required** for an effective collision, therefore there will be a greater number of effective collisions per unit time, therefore a **faster reaction rate**. or more product formed per unit time. Give mark for EITHER point NOT both.

QUESTION 4 RATES OF REACTION

4.1 **Various options each out of 3 marks …** (apparatus measure time)
Place the flask on a scale/weighing apparatus/digital balance and measure the loss in mass over a set time period.
Attach a syringe/gas measuring apparatus to the flask and measure the volume/amount/how much (of) gas produced in a set time period.
Collect the gas (by the downward displacement of water) using an inverted measuring cylinder (or a burette) filled with **water** and measure the volume/amount/how much (of) gas produced in a set time period.

4.2 The particle size/physical state (lump vs granules)/surface area of the calcium carbonate.

4.3 Flask **X**. The smaller the particle size, the **greater the surface area** exposed to the acid. There will be **more effective** (correct orientation and $E_k \geq E_a$) **collisions per unit time** (frequency/chance) and therefore a faster reaction rate. **No marks for flask W** (Apply principle of negative marking.)

4.4 $n = c.V$ ($c = n/V$)
$= 0,1 \times 0,1$ (conversion)
$= 0,01$ mol of $HC\ell$

Mol ratio $HC\ell : CO_2$
2 : 1
0,01 : 0,005

$V = n.Vm$
$= 0,005 \times 22,4$
$= 0,11\ dm^3$ of CO_2 (or $112\ cm^3$)

Award marks for the following skills:
Method to calculate mols of $HC\ell$ ($n = c.V$)
Unit conversion (cm^3 to dm^3)
Applying mol ratio ($HC\ell : CO_2 = 2 : 1$)
Multiplying mols of $CO_2 \times 22,4\ dm^3$
Answer ($0,11\ dm^3$)

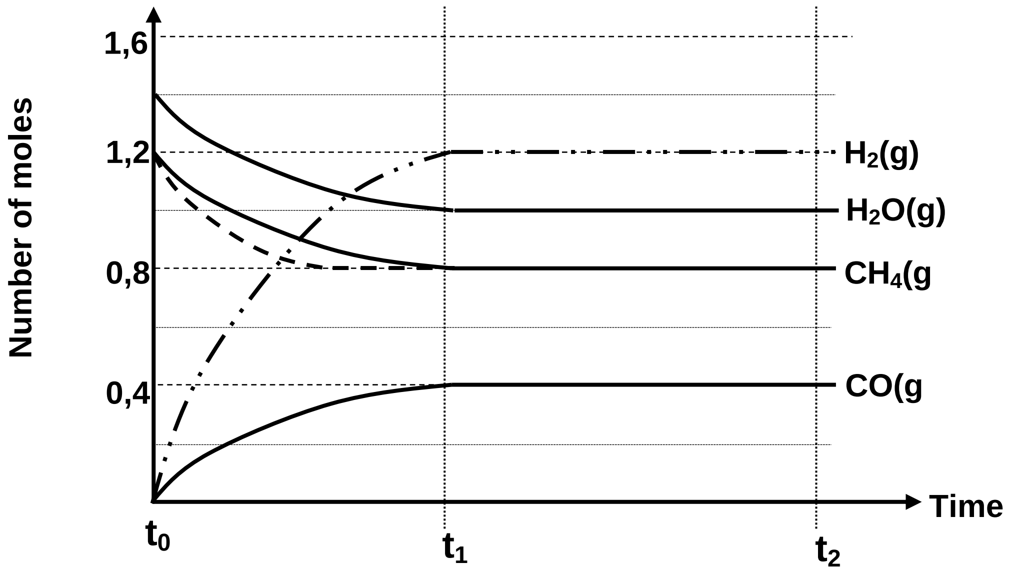
4.5 4.5.1 Equal to

4.5.2 There are **more** molecules /moles/quantity of **acid** to react with the **excess calcium carbonate** therefore producing more carbon dioxide.
OR **More (or bigger volume of)** (molecules/moles/quantity) **acid** which is the **limiting reactant/reagent.**

QUESTION 5 CHEMICAL EQUILIBRIUM

5.1 The reaction is in (dynamic chemical) equilibrium or the **rates** of the forward and reverse reactions are equal or the **rate** of formation of products is equal to the **rate** of formation of reactants.

5.2



5.2.1 Graph levels out at t_1 at 1,2 moles
Between t_0 and t_1 line must be curved (decreasing gradient) as shown. (-1 if H_2 not started at zero)

5.2.2 Graph levels out BEFORE t_1 at 0,8 moles
Between t_0 and t_1 line must be curved (decreasing gradient) as shown (–1) if not. (Allow c.o.e. from 5.2.1.) (-1 if not started at 1,2 mol)

5.3 $K_c = \frac{[CO]\times[H_2]^3}{[CH_4]\times[H_2O]}$ (–1 for use of round brackets)

$K_c = \frac{(0,4/2)\times(1,2/2)^3}{(0,8/2)\times(1/2)}$

$= \mathbf{0,22}$

- Correct moles for reactants
- Correct moles for products (c.o.e. from 5.2.1 if incorrect number of moles used for H_2)
- Divide by volume

5.4 **Low yield of products** (c.o.e. from 5.3) (Answer MUST link to 5.3)

5.5 When an external stress is applied to a system in **chemical equilibrium**, the equilibrium point will change in such a way as to **counteract the stress**

5.6 Explanation using Le Chatelier's Principle
Decrease or low yield of hydrogen. High pressures **favours the reverse reaction** which produces **less moles of gas and relieves the stress of high pressure** or reduces the pressure).
OR Explanation using rates
Decrease or low yield of hydrogen. A high pressure increases the rates of both the forward and reverse reactions but the reverse rate increases more as it **involves more gas particles**, therefore **favours the reverse reaction**.

5.7 No change

5.8 **Faster** reaction **rate**. (Products produced faster.) **Higher yield** of products.

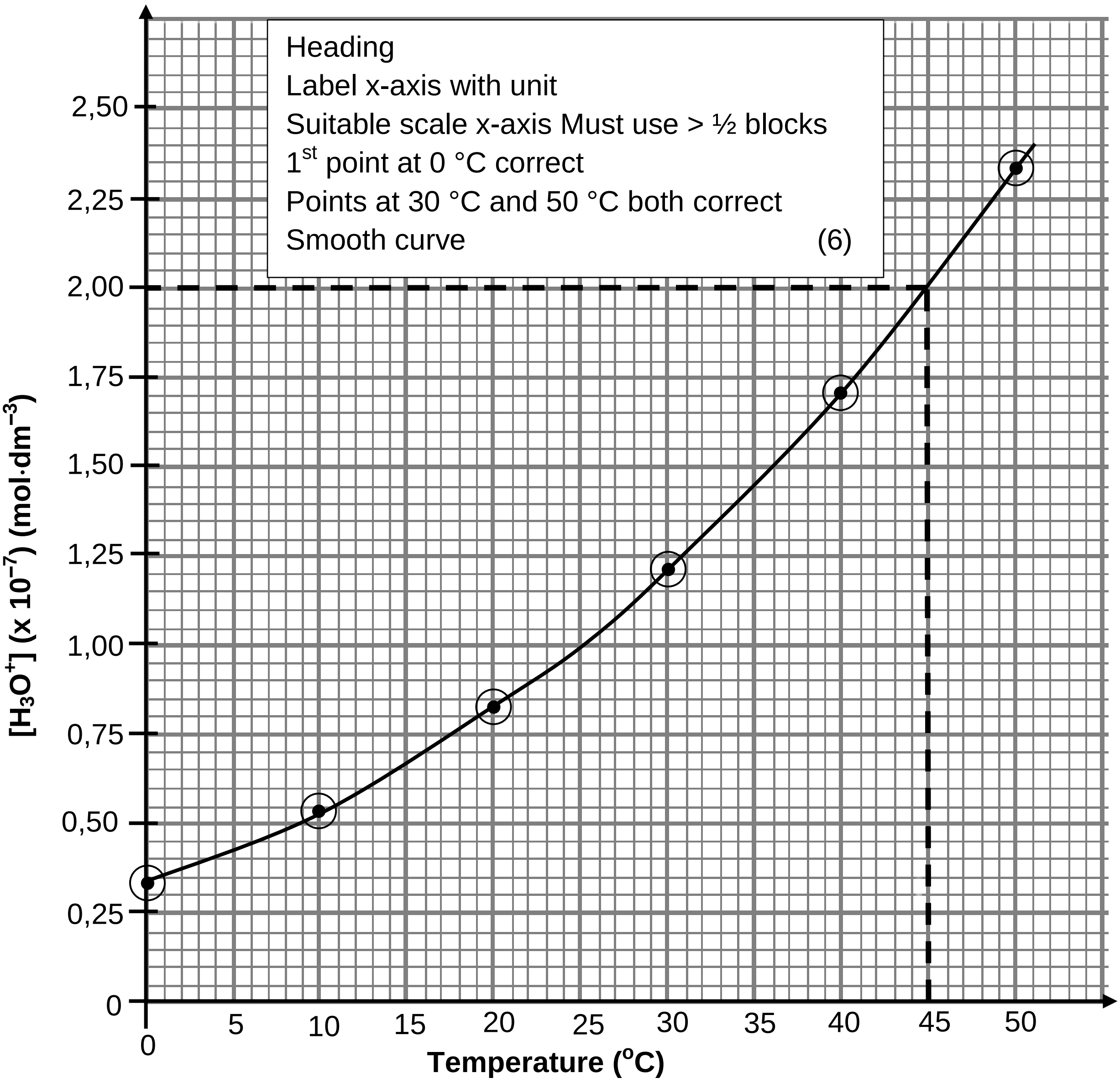
QUESTION 6 EXPERIMENTAL SKILLS AND THE AUTO-IONISATION OF WATER

6.1 $K_w = (1{,}71 \times 10^{-7})^2 = \mathbf{2{,}92 \times 10^{-14}}$

6.2 ENDOTHERMIC since Kw or $[H_3O^+]$ increases (or forward reaction is favoured) with an increase in temperature.

Award marks for the following skills: Linking temperature change to correct shift in equilibrium (either increase temperature favours forward or decrease temperature favours reverse) No marks for EXOTHERMIC.

6.3 **Graph to show the relationship between $[H_3O^+]$ and the temperature (of water)** (order of $[H_3O^+]$ and temperature not important)
OR Graph of $[H_3O^+]$ vs temperature (of water) (order of $[H_3O^+]$ and temperature IS important)



6.4 $[H_3O^+]$ at 45 °C = **2** ($\pm$ 0,05) $\mathbf{\times 10^{-7}}$ **mol·dm^{-3}** (c.o.e. from graph)

If lines indicating where graph was read are not shown (−1)

6.5 It is not a straight line or it does not have a constant gradient ($y/x \neq k$) or it is a curve or it is exponential. It does not pass through the origin.

6.6 6.6.1 Remains the same

6.6.2 Decreases

6.7 Decreases

QUESTION 7 ACIDS & BASES

7.1 An acid is a proton (H^+) donor.

7.2 A concentrated acid has a large amount of acid per unit volume of water. (High proportion of acid to water.) A strong acid ionises (almost) completely in water

7.3 7.3.1 LiOH

7.3.2 H_3PO_4

7.3.3 HNO_3

7.3.4 HCOOH

7.3.5 $NaHCO_3$

7.4 $H_2SO_4 + 2H_2O \rightarrow 2H_3O^+ + SO_4^{2-}$ Reactants Products Balanced

OR $H_2SO_4 + H_2O \rightarrow H_3O^+ + HSO_4^-$

7.5 7.5.1 n = c.V (c=n/V)
= 0,8 × 0,05
= 0,04 mol of HCℓ

7.5.2 n = c.V
= 0,5 × 0,02
= 0,01 mol of NaOH

Therefore 0,01 mol of HCℓ neutralised (excess).

Mols of HCℓ that reacted with MgO = (0,04 – 0,01) (c.o.e from 7.5.1)
= 0,03 mol of HCℓ

Mol ratio: MgO : HCℓ
1 : 2
0,015 : 0,03

Mass of MgO m = n × M
= 0,015 × 40,3
= 0,6045 g of MgO

% of MgO in tablet = 0,6045/0,96 × 100
= 62,97%

OR Assume 100% purity
n= m/M
= 0,96/40,3
= 0,02382134 mol of MgO

But only 0,015 mol of MgO in tablet
% of MgO in tablet = 0,015/0,02382134 × 100
= 62,97%

QUESTION 8 GALVANIC CELLS

8.1 8.1.1 The electrode where oxidation takes place.

8.1.2 A substance that donates electrons (electron donor)

8.2 **Chemical** (potential) energy to **electrical** energy.

8.3 Temperature = **25 °C** (298 K)
Concentration of electrolyte = **1 mol·dm⁻³**
If give 1 atm pressure then give a maximum of 1 mark for either one or both of the other 2 conditions correct.

8.4 $3X + 2Y^{3+} \longrightarrow 3X^{2+} + 2Y$ Reactants Products Balanced
(–1 for double arrow)

8.5 Y^{3+}

8.6 $Z|Z^{+}||X^{2+}|X$ Anode Salt bridge Cathode Ignore balancing numbers.

8.7 X^{2+}

8.8 8.8.1 **Z** strongest

8.8.2 **Y** weakest

8.9 <u>Cell C</u>: $E^{o}_{Cell} = E^{o}$ cathode – E^{o} anode

<u>Cell A</u>: $E^{o}_{Cell\ A} = E^{o}_{Y} - E^{o}_{X}$

$0,84 = E^{o}_{Y} - E^{o}_{X}$ (1)

<u>Cell B</u>: $E^{o}_{Cell\ B} = E^{o}_{X} - E^{o}_{Z}$

$0,68 = E^{o}_{X} - E^{o}_{Z}$ (2)

(1) + (2) $0,84 + 0,68 = E^{o}_{Y} - E^{o}_{X} + E^{o}_{X} - E^{o}_{Z}$

$\mathbf{1,52\ V = E^{o}_{Y} - E^{o}_{Z}}$

Cell C: $\therefore E^{o}_{Cell\ C} = E^{o}_{Y} - E^{o}_{Z}$

$\therefore \mathbf{E^{o}_{Cell\ C} = 1,52\ V}$

QUESTION 9 ELECTROLYTIC CELLS

9.1 In order to **free the ions** from the crystal lattice so that it would **conduct** electricity.

9.2 ANY 2:
Good electrical **conductor**
Inert/unreactive/not readily oxidised or reduced
High melting point (OR solid at high temp)

9.3 9.3.1 $2C\ell^- \rightarrow C\ell_2 + 2e^-$

9.3.2 $Na^+ + e^- \rightarrow Na$

9.3.3 $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

9.4 Na^+

9.5 NaOH or sodium hydroxide or caustic soda

9.6 Either of these points:
In the dilute solution there is relatively more water.
Water is a stronger reducing agent than chloride ions.

Water is oxidised to oxygen.
$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$
No marks for showing oxidation of OH^- ions / H_2O_2

QUESTION 10 ORGANIC CHEMISTRY (1)

10.1 10.1.1 Esters

10.1.2 butyl ethanoate

10.1.3 ethanoic acid c.o.e. from 10.1.2 (must make link)

10.1.4 $C_6H_{12}O_2 + 8O_2 \rightarrow 6CO_2 + 6H_2O$ Reactants Products Balancing

10.1.5 Isomers are *compounds having the same molecular formula but different structural formulae.*

10.1.6 (a) ethyl butanoate or propyl propanoate or methyl pentanoate or pentyl methanoate

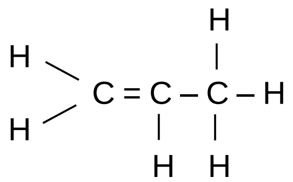
(b) hexanoic acid hex anoic acid no c.o.e. from 10.1.2

10.2 10.2.1 substitution (hydrolysis)

10.2.2 $CH_3CHC\ell CH_3 + NaOH \rightarrow CH_3CHOHCH_3 + NaC\ell$
(structural or molecular formulae –1)

Award marks for the following:	
2-chloropropane	3C's rest of formula correct
Propan-2-ol	OH group (knowing it's an alcohol)
	rest of formula
$NaC\ell$	

10.2.3



C = C rest of formula correct

-1 if use condensed structural formula

QUESTION 11 ORGANIC CHEMISTRY (2)

11.1 Cracking

11.2 A saturated hydrocarbon is a compound containing only **carbon and hydrogen atoms** in which all of the bonds **between carbon atoms** are **single bonds**.

11.3 Alkanes

11.4 The **hydrocarbons** have **induced dipole forces or London forces** between their molecules.
Water has **hydrogen bonds** between its molecules.
Hydrogen bonds are **STRONGER** than London forces or the intermolecular forces of the hydrocarbons are **not similar in STRENGTH** to those of water. (either point for 1 mark) therefore insoluble.
OR **Dipole induced-dipole forces** between the hydrocarbon molecules and the water solvent are **weaker than** the **hydrogen bonds** between the water molecules therefore insoluble.

11.5 11.5.1 Ethene

11.5.2 Addition (halogenation, bromination)

11.6 2,2–dimethylbutane 2,2 – dimethyl but ane

11.7

11.7.1 2 molecules of X = (12C + 26H) – (4C + 10H) – (2C + 4H)
(OR $C_{12}H_{26}$ – C_4H_{10} – C_2H_4)
= 6C + 12H or C_6H_{12}
(÷ 2)
1 molecule of X = 3C and 6H
∴ Compound X = $\mathbf{C_3H_6}$

OR $C_{12}H_{26}$
– C_4H_{10}
– C_2H_4
C_6H_{12} ÷ 2 **=** $\mathbf{C_3H_6}$

Award marks for the following skills:
Subtraction (from 12C + 26H or $C_{12}H_{26}$) to get C_6H_{12} (award subtraction mark if candidate arrived at C_6H_{12} without explicitly showing the subtraction)
Dividing by 2
Correct final answer ($\mathbf{C_3H_6}$)

11.7.2 All hydrocarbons have **induced dipole forces or London forces** between their molecules.
The **larger kerosene molecules** have a **greater interactive surface** and have **a greater electron density**.
Bigger temporary dipoles are set up or **easier dispersion of electrons** therefore **longer lasting dipoles.**
These factors result in **STRONGER** London forces.
More energy is needed to overcome the stronger intermolecular forces (**NOT bonds**) or to separate the molecules therefore kerosene is a liquid at room temperature (higher b.pt.).

Total: 200 marks