



NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY EXAMINATION 2015

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

- | | | | |
|-----|---|------|---|
| 1.1 | B | 1.6 | D |
| 1.2 | D | 1.7 | B |
| 1.3 | D | 1.8 | A |
| 1.4 | D | 1.9 | B |
| 1.5 | A | 1.10 | B |

[20]

QUESTION 2

- 2.1 2.1.1 Family of organic molecules that are identified by the same functional group and obey the same general formula (differ by a CH₂ unit) (2)
- 2.1.2 A molecule made up of C and H atoms only and have a double or triple bond between the C atoms in the chain (not all the bonds to the C atoms are singularly occupied) (4)
- 2.2 2.2.1 (a) Alkenes
(b) Carboxylic acids
(c) Alkenes (3)
- 2.2.2 (a) Chlorine (accept chloro) or halo
(b) Hydroxyl
(c) Carboxyl (3)
- 2.2.3 G: Pentanoic acid (2)
H: 2 – methylpropene (2)
- 2.2.4 (a) **Methanol** **Propanoic Acid**
- $$\begin{array}{c} \text{H} \\ | \\ \text{H}-\text{C}-\text{OH} \\ | \\ \text{H} \end{array}$$

$$\begin{array}{ccccc} & \text{H} & & \text{H} & & \text{O} \\ & | & & | & & || \\ \text{H} & -\text{C} & - & \text{C} & - & \text{C} & -\text{OH} \\ & | & & | & & \\ & \text{H} & & \text{H} & & \end{array}$$
- (4)
- (b) Esterification/elimination (1)
- (c) To act as a dehydrating agent
To act as a catalyst (2)

$$2.2.5 \quad (a) \quad n = \frac{m}{M}$$

$$= \frac{108}{44}$$

$$N = 2,46 \text{ mol of } C_3H_8 \quad (2)$$

$$(b) \quad C_3H_8 : O_2$$

$$1 : 5$$

$$n(O_2) = \frac{2,46}{1} \times 5$$

$$n(O_2) = 12,30 \text{ mol}$$

$$V = nV_m$$

$$= 12,30 \times 22,4$$

$$V = 275,52 \text{ dm}^3 \quad (3)$$

$$(c) \quad C_3H_8 : CO_2$$

$$1 : 3$$

$$n(CO_2) = 2,46 \times 3$$

$$= 7,38 \text{ mol of } CO_2$$

Carry over

$$m = nM$$

$$= 7,38 \times 44$$

$$m = 324,72 \text{ g of } CO_2 \quad (3)$$

$$(d) \quad \text{Total volume of } O_2 = 275,52 + 67,2$$

$$= 342,72 \text{ dm}^3$$

$$n = \frac{V}{V_m}$$

$$= \frac{342,72}{22,4}$$

$$n = 15,30 \text{ mol of } O_2$$

$$\therefore n(C_3H_8) = \frac{15,30}{5}$$

$$n(C_3H_8) = 3,06 \text{ mol}$$

$$\therefore \text{Extra } C_3H_8 = 3,06 - 2,46$$

$$= 0,6 \text{ mol}$$

$$m = nM$$

$$= 0,6 \times 44$$

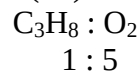
$$m = 26,4 \text{ g of } C_3H_8 \quad (4)$$

Alternative:

$$n(O_2) = \frac{V}{V_m}$$

$$= \frac{67,2}{22,4}$$

$n(O_2) = 3 \text{ mol excess}$



$$\therefore n(C_3H_8) = 0,6 \text{ mol extra}$$

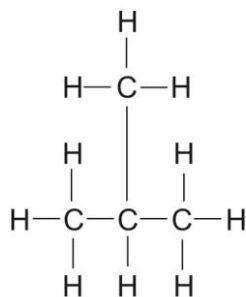
$$n = \frac{m}{M}$$

$$= \frac{0,6 \times 44}{44}$$

$$n = 0,6 \text{ mol}$$

$$2.2.6 \quad (a) \quad \text{Molecules with the same molecular formula but differing structural formula} \quad (2)$$

(b)



Methylpropane
(2 – methylpropane)

(4)

(c) methylpropane (the second isomer in Question 2.2.6 (b))

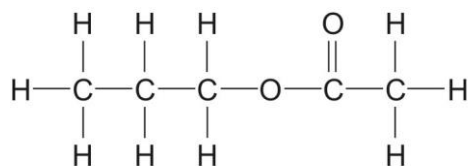
- has a smaller surface area than butane or
- smaller electron cloud density thus fewer points of contact for attraction
- intermolecular forces will thus be weaker
- less energy needed to overcome these forces, thus lower boiling point

(4)

2.2.7 (a) Isomers of an organic compound which have different functional groups hence belong to different homologous series

(2)

(b)



Propyl ethanoate
(methyl butanoate, ethyl propanoate, butyl methanoate)

(4)

2.2.8 (a) E = elimination
H = addition
A = substitution

(3)

(b) Dehydration

(2)

[56]

QUESTION 3

3.1 Reactant is being used up (few collisions between reacting particles)
(concentration of reactant decreases) (2)

3.2 5 minutes (1)

3.3 Substance that speeds up a chemical reaction without itself undergoing a chemical change (2)

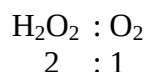
3.4 0,1 g (remains the same) (2)

3.5 O_2 produced = 120 cm^3

$$n = \frac{V}{V_m}$$

$$= \frac{0,12}{22,4}$$

$$n = 5,36 \times 10^{-3} \text{ mol (0,00536 mol)}$$



$$\therefore n(H_2O_2) \text{ used} = 5,36 \times 10^{-3} \times 2$$

$$= 1,07 \times 10^{-2} \text{ mol (0,00107 mol)}$$

$n(H_2O_2)$ at start

$$c = \frac{n}{V}$$

$$n = cV$$

$$= 0,2 \times 0,2$$

$$= 0,04 \text{ mol}$$



$n(H_2O_2)$ left

$$= 0,04 - 0,00107$$

$$= 0,0389 \text{ mol}$$

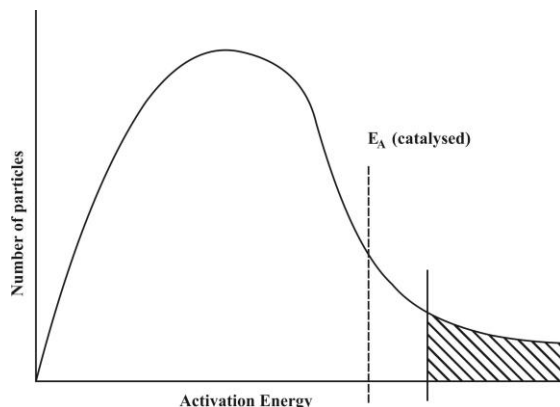
$$C = \frac{n}{V}$$

$$= \frac{0,0389}{0,2}$$

$$C = 0,195 \text{ mol} \cdot \text{dm}^{-3} \quad (6)$$

3.6 3.6.1 Catalyst lowers the activation energy needed for effective collision. More particles will have required energy for effective collisions, thus more frequent collisions making reaction faster (4)

3.6.2



(2)
[19]

QUESTION 4

4.1 $2,2 \times \frac{3}{2} = 3,3 \text{ mol}$ (2)

4.2 $\text{N}_2 : \text{H}_2$
1 : 3
 $n(\text{N}_2) = \frac{3,3}{3}$ ← Carry over
= 1,1 mol
Moles remaining = 3 – 1,1
= 1,9 mol (3)

4.3 $3,3 + 1,5$
= 4,8 mol of H_2 (2)

4.4 $K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$ (2)

4.5 $c = \frac{n}{V}$
 $[\text{N}_2] = \frac{1,9}{0,25} = 7,6 \text{ mol} \cdot \text{dm}^{-3}$ $[\text{H}_2] = \frac{1,5}{0,25} = 6 \text{ mol} \cdot \text{dm}^{-3}$ $[\text{NH}_3] = \frac{2,2}{0,25} = 8,8 \text{ mol} \cdot \text{dm}^{-3}$
 $K_c = \frac{(8,8)^2}{(7,6)(6)^3}$
 $K_c = 0,0472 (4,72 \times 10^{-2})$ (5)

4.6 When an isolated/closed system in a state of dynamic chemical equilibrium is subjected to a disturbance/stress the equilibrium position will change in such a way as to minimise the disturbance (3)

4.7 Exothermic

- decrease in temperature favours the exothermic reaction
 - decrease in $[\text{H}_2]$ and $[\text{N}_2]$ means K_c increases
 - Increase in K_c means forward reaction is favoured
- (4)
[21]

QUESTION 5

5.1 Acid = proton donor
Base = proton acceptor (2)

5.2 5.2.1 **Ionisation** – process where a non-ionic substance dissolves in water to produce ions for the first time

Dissociation – process where an ionic crystal lattice breaks up to release ions into solution (4)

5.2.2 (a) **Strong acid** – acid that will tend towards complete ionisation in aqueous solution (2)

(b) **Weak base** – basic substance that will only partially dissociate in solution (2)

5.2.3 $\text{HNO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{NO}_3^-$ (3)

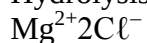
5.3 5.3.1 • the process where an acid and a base react to form salt and water, or
• process whereby the acid and base components within a chemical reaction are cancelled out (2)

5.3.2 $c = \frac{n}{V}$
 $n = cV$
 $= 0,2 \times \frac{20}{1000}$
 $n = 0,004 \text{ mol } (4 \times 10^{-3} \text{ mol})$ (3)

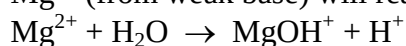
5.3.3 $\text{Mg}(\text{OH})_2 : \text{HCl}$
 $1 : 2$
 $x : 4 \times 10^{-3}$
 $n(\text{Mg}(\text{OH})_2) = \frac{4 \times 10^{-3}}{2}$
 $= 2 \times 10^{-3} \text{ mol}$
 $n = \frac{m}{M}$ $M(\text{Mg}(\text{OH})_2) = 58,3 \text{ g} \cdot \text{mol}^{-1}$
 $m = nM$
 $= 2 \times 10^{-3} \times 58,3$
 $m = 0,117 \text{ g}$ (5)

5.3.4 Bromocresol green

Hydrolysis is the ability of ions of the salt to react with water molecules

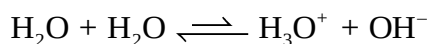


Mg^{2+} (from weak base) will react with H_2O



H^+ increases the acidity of the solutions $\therefore \text{pH}$ of the solution < 7

OR



- Mg^{2+} (from weak base) will react with OH^- .
- OH^- ions removed from solution therefore H_2O will ionise to replace OH^- ions, i.e. forward reaction is favoured.
- More H_3O^+ produced, therefore solution is **acidic**.

(4)
[27]

QUESTION 6

- 6.1 6.1.1 H_2O and HCl
 6.1.2 CH_4 and CO_2
 6.1.3 H_2O
 6.1.4 C
 6.1.5 KCl
 6.1.6 KCl (8)
- 6.2 6.2.1 Dipole-dipole (1)
- 6.2.2 • molecules are increasing in size
 • increase in electron cloud density allowing for more points of contact where attraction can take place (3)
- 6.2.3 H_2O • hydrogen bonding intermolecular forces
 • much stronger than dipole-dipole attractive forces
 • more energy required to overcome these forces (3)
- [15]

QUESTION 7

- 7.1 Electrolyte concentration = $1 \text{ mol} \cdot \text{dm}^{-3}$
 Temperature = 25°C
 Pressure = 1 atmosphere / 101 kPa / $1,01 \times 10^5 \text{ Pa}$ (3)
- 7.2 CuSO_4 / $\text{Cu}(\text{NO}_3)_2$ / CuCl_2 (2)
- 7.3 7.3.1 $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$ (2)
- 7.3.2 $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$ (2)
- 7.3.3 $\text{Cu} + \text{Cl}_2 \rightarrow \text{Cu}^{2+} + 2\text{Cl}^-$ (–1 for any error) (2)
- 7.4 $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$
 = $1,36 - 0,34$
 = $1,02\text{V}$ (4)
- 7.5 $\text{Cu}/\text{Cu}^{2+} (1 \text{ mol} \cdot \text{dm}^{-3}) // \text{Cl}_2 / \text{Cl}^- (1 \text{ mol} \cdot \text{dm}^{-3}) / \text{Pt}$ (4)
- 7.6 • Pt is an inert metal (must not react electrochemically in the cell)
 • Pt is a good conductor of electricity (2)
- 7.7 Potassium chloride/Sodium nitrate (etc.) (2)

- 7.8
- anode – increase in concentration of cations
 - cathode – decrease in concentration of cations
 - ionic imbalance – ions from salt bridge move to each half cell to maintain ionic balance
 - cations move into cathode half-cell anions move into anode half-cell
- (4)
[27]

QUESTION 8

8.1 Brine (1)

8.2 To act as an ion – selective membrane which only allows Na^+ ions to pass through into the cathode (2)

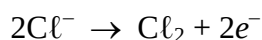
8.3 $2\text{H}_2\text{O} + 2e^- \rightarrow \text{H}_2 + 2\text{OH}^-$ (2)

8.4 $\text{Na}^+(\text{aq})$ and H_2O present in cathode chamber

- H_2O is a stronger oxidising agent than $\text{Na}^+(\text{aq})$
- H_2O is reduced at the cathode
or $2\text{H}_2\text{O} + 2e^- \rightarrow \text{H}_2 + 2\text{OH}^-$

(2)

8.5 $Q = It$
 $= 4\,000 \times 150$
 $Q = 600\,000\text{ C}$



Method 1

$$\begin{aligned} 1 \text{ mol of } e^- &= 96\,500\text{ C} \\ \therefore n(e^-) &= \frac{600\,000}{96\,500} \\ \therefore n(e^-) &= 6,22 \text{ mol of } e^- \end{aligned}$$

$$\begin{aligned} \text{Cl}_2 : e^- \\ 1 : 2 \\ n(\text{Cl}_2) &= \frac{6,22}{2} \\ \therefore n(\text{Cl}_2) &= 3,11 \text{ mol of } \text{Cl}_2 \end{aligned}$$

$$\begin{aligned} n &= \frac{V}{V_m} \\ V &= nV_m \\ &= 3,11 \times 22,4 \\ V &= 69,66 \text{ dm}^3 \text{ of } \text{Cl}_2 \end{aligned}$$

Method 2

$$\begin{aligned} 1e^- &= 1,6 \times 10^{-19} \text{ C} \\ \therefore \text{no of } e^- &= \frac{600\,000}{1,6 \times 10^{-19}} \\ n(e^-) &= 3,75 \times 10^{24} e^- \end{aligned}$$

$$\begin{aligned} n &= \frac{N}{N_A} \\ &= \frac{3,75 \times 10^{24} e^-}{6,02 \times 10^{23}} \\ n &= 6,23 \text{ mol} \end{aligned}$$

$$\begin{aligned} \text{Cl}_2 : e^- \\ 1 : 2 \\ n(\text{Cl}_2) &= \frac{6,23}{2} \\ &= 3,12 \\ n &= \frac{V}{V_m} \\ V &= nV_m \\ &= 3,12 \times 22,4 \\ V &= 69,89 \text{ dm}^3 \text{ of } \text{Cl}_2 \end{aligned}$$

(8)

[15]

Total: 200 marks