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SUBJECT: SUBJECT NAME

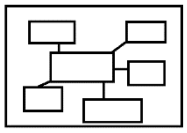
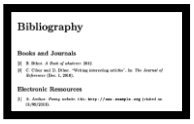
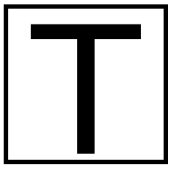
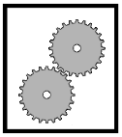
GRADE 12

LAST PUSH 2026

TEACHER SOLUTIONS MANUAL

PAPER 2: CHEMISTRY

ICON DESCRIPTION

 MIND MAP	 EXAMINATION GUIDELINE	 CONTENTS	 ACTIVITIES
 BIBLIOGRAPHY	 TERMINOLOGY	 WORKED EXAMPLES	 STEPS



CONTENTS **PAGE**

1. ORGANIC MOLECULES	2-12
2. RATES AND EXTENT OF REACTIONS	12-17
3. CHEMICAL EQUILIBRIUM	18-30
4. ACIDS AND BASES	30-36
5. ELECTROCHEMICAL REACTIONS	37-42

TOPIC 1: ORGANIC MOLECULES

A. STRUCTURE AND NOMENCLATURE

QUESTION 1

1.1 1.1.1 D. ✓

1.1.2 A and C. ✓

1.1.3 E and F. ✓

1.2 1.2.1. 3-methylbutan-2-one ✓✓✓ /3-methylbutanone.

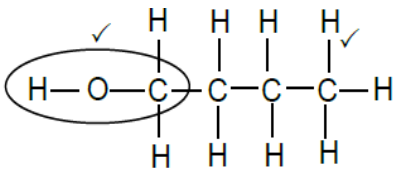
ACCEPT

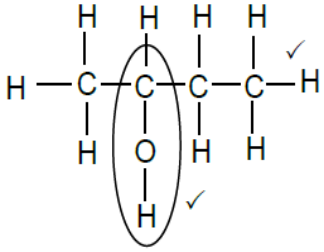
3-methyl-2-butanone/ methylbutanone.

1.2.2. 2,6-dichloro-2,5-dimethylheptane. ✓✓✓

1.2.3. 3-ethyl-2-methylhex-2-ene. ✓✓✓ /3-ethyl-2-methyl-2-hexene.

1.2.4





1.3 1.3.1 Combustion/oxidation. ✓

1.3.2

OPTION 1/*OPSIE 1*:

$V(O_2)_{used/gebruik} = 5V(C_3H_8)$
$= (5)(8)$
$= 40\ cm^3$ ✓ (a)

$V(CO_2)_{formed/gevrom} = 3V(C_3H_8)$
$= (3)(8)$
$= 24\ cm^3$

$V(H_2O)_{formed/gevrom} = 4V(C_3H_8)$
$= (4)(8)$
$= 32\ cm^3$ ✓ (b)

$V(O_2)_{unused} = 50 - 40 = 10\ cm^3$ ✓ (c)

Volume gas in the container = 10 + 24 + 32 ✓ (d)
Total volume gas in the container = 66 cm^3 ✓ (e)

OPTION 2/ *OPSIE 2*:

	C_3H_8	O_2	CO_2	H_2O
Initial volume (cm^3) *Aanvanklike volume* (cm^3)	8	50	0	0
Change volume (cm^3) ✓ (a) *Verandering in volume* (cm^3)	-8	-40	24	32 ✓ (b)
Final volume (cm^3) *Finale volume* (cm^3)	0	10 ✓ (c)	24	32
Total volume of gases in container (cm^3) *Totale volume gas in houer* (cm^3)		10 + 24 +32 ✓ (d) = 66 cm^3 ✓ (e)		

ACCEPT/AANVAAR:
If subtraction not shown, give mark for the 10 cm^3/
Indien aftrekking nie getoon, gee punt vir 10 cm^3.

$n(C_3H_8) : n(O_2) : n(CO_2) : n(H_2O)$
1 : 5 : 3 : 4

V = 8 ✓ (a) 40 24 ✓ (b) 32

Total volume = 10 + 24 + 32 ✓ (c) ✓ (d)
= 66 cm^3 ✓ (e)

QUESTION 2

2.1 2.1.1 D. ✓
2.1.2 A. ✓
2.1.3 E. ✓

2.2 2.2.1 3,3-dibromo-4,4-dimethylhexane. ✓✓✓
2.2.2 4,4-dimethylpent-2-yne/4,4-dimethyl-2-pentyne. ✓✓✓

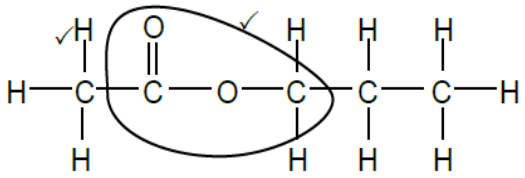
2.3 2.3.1 Compounds with the same molecular formula,✓ but different functional groups/homologous series. ✓

2.3.2 A and C. ✓

2.4 2.4.1 H_2SO_4/Sulphuric acid. ✓

2.4.2 Esterification/Condensation. ✓

2.4.3



2.4.4 Propan-1-ol/1-propanol. ✓ ✓

QUESTION 3

3.1 Compounds with one or more multiple bonds between C atoms in the hydrocarbon chain. ✓✓

OR

A hydrocarbon with two or more bonds between the C-atoms.

OR

Hydrocarbons containing not only single bonds between C atoms.

ACCEPT:

Compounds with one or more double/triple bonds between C atoms in the hydrocarbon chain.

3.2 3.2.1 E. ✓

3.2.2 F. ✓

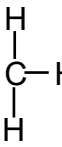
3.3 Ketones ✓

Aldehydes. ✓

3.4 Tertiary. ✓

The hydroxyl group/functional group (-OH) is bonded to a C atom that is bonded to three other C atoms. ✓

OR

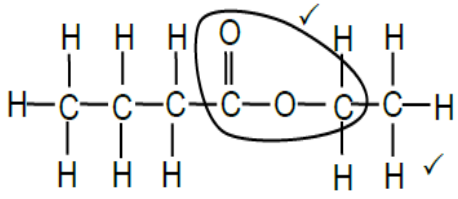
The functional group () is bonded to three other C atoms.

3.5 3.5 1 3-ethyl-4-iodohexane. ✓ ✓ ✓

3.5.2 2-methylpropan-1-ol/ 2-methyl-1-propanol/ methylpropan-1-ol/ methyl-1-propanol. ✓✓

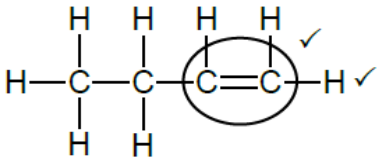
3.6 3.6.1 Esterification/Condensation. ✓

3.6.2



3.7 3.7.1 C_2H_4O ✓

3.7.2



QUESTION 4

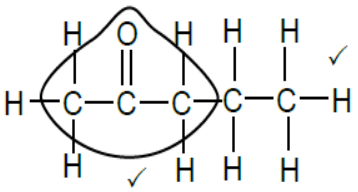
4.1 Organic compounds that consist of hydrogen and carbon only. ✓✓

4.2 4.2.1 C and E. ✓

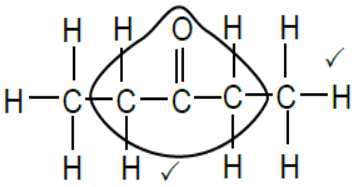
4.2.2 D and H. ✓✓

4.2.3 A. ✓

4.3 4.3.1

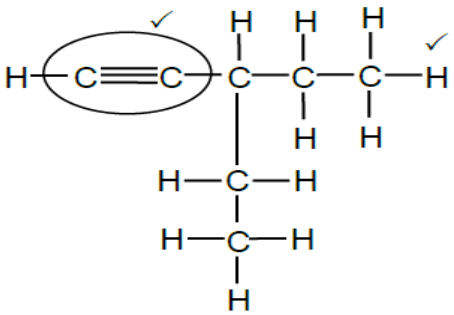


OR/OF



4.3.2 C_nH_{2n+2} ✓

4.3.3



4.4 4.4.1 3-ethylhex-3-ene ✓✓✓/3-ethyl-3-hexene.

4.4.2 2,5-dichloro-2,4-dimethylhexane ✓✓✓

4.4.3 2,2-dimethyl✓propanal✓/dimethylpropanal.

4.5 C_7H_{16}✓ + $11O_2 \rightarrow 7CO_2 + 8H_2O$ ✓ Bal ✓

B. PHYSICAL PROPERTIES

QUESTION 1

1.1 1.1.1 (A series of organic) compounds that can be described by the same general formula. ✓✓

OR

(A series of organic) compounds in which one member differs from the next by a CH_2 group.

1.1.2 (a) Formyl (group). ✓

(b) Methanal. ✓

1.1.3 (a) Homologous series/Functional group/Type of intermolecular forces/Straight chain/Atmospheric pressure. ✓

(b) The boiling points of the carboxylic acids increase with an increase in the chain length/the number of carbon atoms/ surface area/molecular mass. ✓

OR

The boiling points of the carboxylic acids decrease with a decrease in the chain length/number of carbon atoms/surface area/molecular mass.

(c) As the number of C atoms/chain length/surface area/contact area/molecular mass increases:

- The strength of intermolecular/London/dispersion forces increases. ✓
- More energy is needed to overcome intermolecular forces/London/ dispersion forces. ✓

OR

As the number of C atoms/chain length/surface area/contact area/molecular mass decreases:

- The strength of intermolecular/London/dispersion forces decreases. ✓
- Less energy is needed to overcome intermolecular forces/London/ dispersion forces. ✓

1.1.4 75 °C. ✓

1.2

- Higher than ✓
- Compound B/$CH_3CH_2CH_2COOH$/Carboxylic acid/Butanoic acid has (in addition to London forces and dipole-dipole forces), more than one site (two) for hydrogen bonding between molecules and compound A/$CH_3CH_2CH_2CH_2CH_2OH$/Alcohol/Pentan-1-ol has (in addition to London forces and dipole-dipole forces) one site for hydrogen bonding between molecules. ✓
- Intermolecular forces in compound B/$CH_3CH_2CH_2COOH$/Carboxylic acids/Butanoic acid are stronger. ✓
- More energy needed to overcome/break intermolecular forces in compound B/ $CH_3CH_2CH_2COOH$/Carboxylic acid/Butanoic acid.

OR

- At a given temperature there will be fewer molecules of compound B/$CH_3CH_2CH_2COOH$/Carboxylic acids/Butanoic acid in the vapour phase. ✓

- Higher than ✓
- Compound A/$CH_3CH_2CH_2CH_2CH_2OH$/Alcohol/Pentan-1-ol has (in addition to London forces and dipole-dipole forces) one site for hydrogen bonding between molecules and compound B/$CH_3CH_2CH_2COOH$/ Carboxylic acid/Butanoic acid has, (in addition to London forces and dipole-dipole forces), more than one site (two) for hydrogen bonding between molecules. ✓
- Intermolecular forces in compound A/$CH_3CH_2CH_2CH_2CH_2OH$/Alcohol/ Pentan-1-ol are weaker. ✓
- Less energy needed to overcome/break intermolecular forces in compound A/$CH_3CH_2CH_2CH_2CH_2OH$/Pentan-1-ol/Alcohol.

OR

- At a given temperature there will be more molecules of compound A/$CH_3CH_2CH_2CH_2CH_2OH$/Alcohol/ Pentan-1-ol in the vapour phase. ✓

QUESTION 2

2.1 The pressure exerted by a vapour at equilibrium with its liquid in a closed system. ✓✓

2.2 2.2.1 146 (kPa). ✓

Accept:
146 000 Pa.

2.2.2 **Comparing compound C/2,2-dimethylpropane with compounds A/ pentane and B/2-methylbutane.**

- **Structure:**
  Compound **C** is more branched than compounds **A** and **B**/Shorter chain length/most compact most spherical/smallest surface area (over which intermolecular forces act). ✓
- **Intermolecular forces:**
  Compound **C** has weaker/less intermolecular forces/Van der Waals forces/London forces than **A** and **B.** ✓
- **Energy:**
  Lesser energy needed to overcome or break intermolecular forces/ Van der Waals force in compound **C** than A and **B**. ✓

2.3 2.3.1 E/butanal. ✓

- Compound **D**/Propanoic acid has hydrogen bonding (dipole-dipole and London forces) between molecules. ✓
- Compound **E**/Butanal has dipoledipole forces (and London forces) between molecules. ✓
- Intermolecular forces between molecules of compound **D**/propanoic acid are stronger than intermolecular forces between molecules of compound **E**/butanal. ✓
- More energy is needed to overcome/break intermolecular forces between molecules of compound **D**/propanoic acid than in compound **E**/butanal. ✓

OR

- Compound **D**/Propanoic acid has hydrogen bonding (dipoledipole and London forces) between molecules**.**
- Compound **E**/Butanal has dipoledipole forces (and London forces) between molecules**.**
- Intermolecular forces between molecules of compound **E**/butanal are weaker than intermolecular forces between compound **D**/propanoic acid.
- Lesser energy is needed to overcome/break intermolecular forces between molecules of compound **E**/butanal than in compound **D**/propanoic acid.

QUESTION 3

3.1 The temperature at which the vapour pressure (of a substance) equals atmospheric pressure. ✓ ✓

3.2 C. ✓

3.3 **A/$CH_3CH_2CH_2CH_2C\ell$ /1-chlorobutane:**

- **Structure:**
  Longer chain length/larger surface area (over which intermolecular forces act). ✓
- **Intermolecular forces:**
  Stronger/more intermolecular forces/Van der Waals forces/London forces/dipole-dipole forces. ✓
- **Energy:**
  More energy needed to overcome or break intermolecular forces/ Van der Waals forces/dipole-dipole forces. ✓

OR

B/$CH_3CH(CH_3)CH_2C\ell$/1-chloro-2-methylpropane:

- **Structure:**
  Shorter chain length / branched / compact / more spherical / smaller surface area (over which intermolecular forces act). ✓
- **Intermolecular forces:**
  Weaker/less intermolecular forces/Van der Waals forces/London forces/ dipole-dipole forces. ✓
- **Energy:**
  Less energy needed to overcome or break intermolecular forces/Van der Waals forces/dipole-dipole forces. ✓

3.4 3.4.1 75 (°C). ✓

3.4.2 • **Intermolecular forces:**
C ($CH_3CH_2CH_2CH_2OH$/butanol) has stronger intermolecular forces than **D** ($CH_3CH_2CH_2CHO$/butanal). ✓

- **Energy:**
  More energy needed to overcome or break intermolecular forces. ✓
  Accept: Boiling point of **C** will be more (in relation to **C** and **D**/118°C vs 75°C).

OR

- **Intermolecular forces:**
  D ($CH_3CH_2CH_2CHO$/butanal) has weaker intermolecular forces than **C** ($CH_3CH_2CH_2CH_2OH$/butanol). ✓
- **Energy:**
  Less energy is needed to overcome or break intermolecular forces.
  Accept: Boiling point of **D** will be less (in relation to **C** and **D**/118°C vs 75°C).

OR

- **Intermolecular forces:**
  A (CH3CH2CH2CH2Cℓ) is a more polar molecule than **D** ($CH_3CH_2CH_2CHO$) increasing the intermolecular forces. ✓
- **Energy:**
  More energy is needed to overcome or break intermolecular forces.
  Accept: Boiling point of **D** will be less (in relation to **A** and **D**). ✓

OR

- **Intermolecular forces:**
  Electron density of **A** ($CH_3CH_2CH_2CH_2C\ell$) is greater than **D** ($CH_3CH_2CH_2CHO$) increasing the intermolecular forces. ✓
- **Energy:**
  More energy is needed to overcome or break intermolecular forces.
  Accept: Boiling point of **D** will be less (in relation to **A** and **D**).

3.5 Decreases. ✓

QUESTION 4

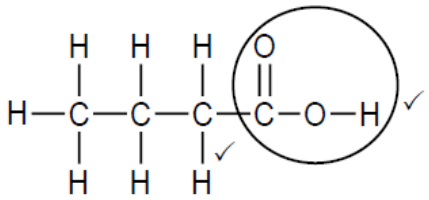
4.1 A series of organic compounds that can be described by the same general formula. ✓ ✓

OR

A series of organic compounds in which one member differs from the next by a CH_2 group.

4.2 Ester ✓ and carboxylic acid. ✓

4.3 4.3.1



4.3.2 Methyl propanoate/Propyl methanoate/Ethyl ethanoate. ✓✓

4.4 4.4.1 Hydrogen bonds. ✓

4.4.2 Dipole-dipole forces. ✓

4.5 A. ✓

The hydrogen bond is stronger than the dipole-dipole force. ✓

OR

The dipole-dipole force is weaker than the hydrogen bonds.

OR

Compound **A** has stronger intermolecular forces (than **B**).

OR

Compound **B** has weaker intermolecular forces (than **A**).

4.6 Decreases. ✓

C. ORGANIC REACTIONS

QUESTION 1

1.1 1.1.1 Hydrogenation. ✓

1.1.2 Dehydration. ✓

1.2 Butan-1-ol/1-butanol

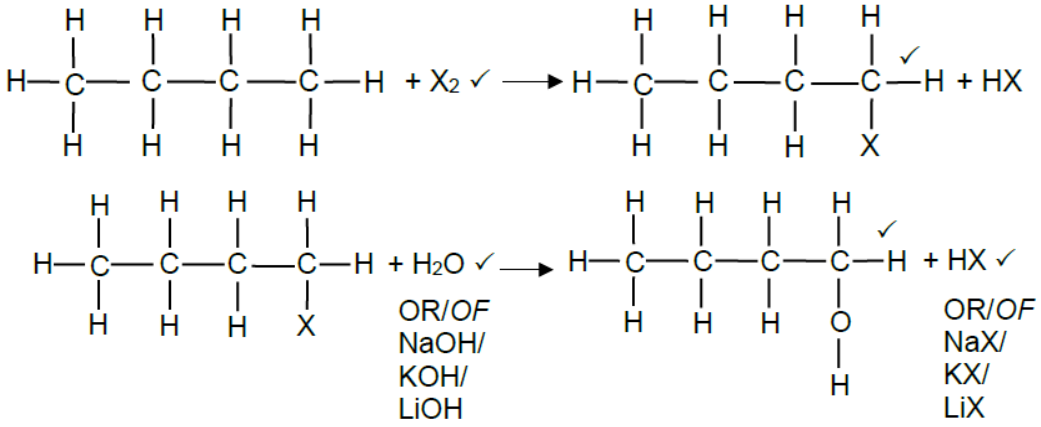
1.3 1.3.1 $CH_2CHCH_2CH_3$ ✓ + H_2O ✓ → $CH_3CHOHCH_2CH_3$ ✓✓

OR

$CH_2{=}CHCH_2CH_3$ ✓ + H_2O ✓ → $CH_3\overset{\overset{OH}{|}}{C}HCH_2CH_3$ ✓✓

1.3.2 Sulphuric acid/H_2SO_4/Phosphoric acid/H_3PO_4. ✓

1.4



1.5 $2C_4H_{10}$ ✓ + $13O_2 \rightarrow 8CO_2 + 10H_2O$ ✓ Bal. ✓

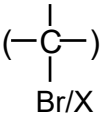
QUESTION 2

2.1 The chemical process/reaction in which longer chain hydrocarbon/alkane molecules/are broken down to shorter (more useful) molecules. ✓✓

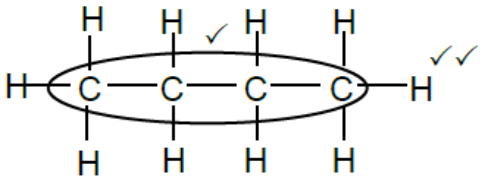
2.2 Primary. ✓

The halogen/bromine/functional group (-X) is bonded to a C atom that is bonded to one other C atom. ✓

OR

The functional group () is bonded to one other C atom.

2.3 2.3.1



2.3.2 C_8H_{18}. ✓

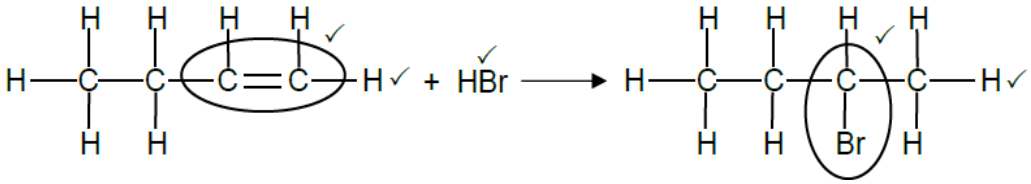
2.4 2.4.1 Br_2/Bromine. ✓

2.4.2 Substitution. ✓

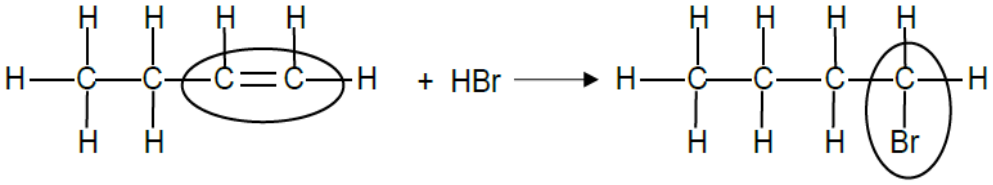
2.4.3 UV/(Sun)light/Heat. ✓

2.5 Dehydrohalogenation/Dehydrobromination. ✓

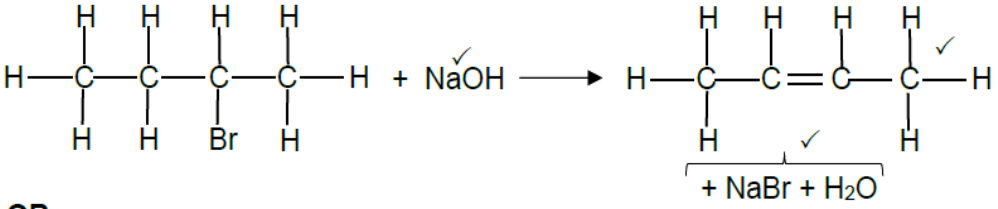
2.6 2.6.1



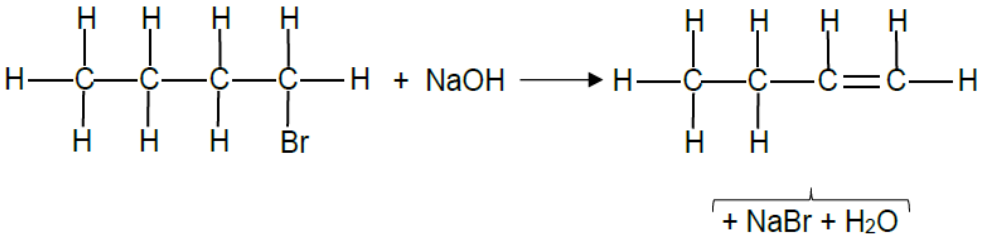
OR



2.6.2



OR



2.6.3 But-2-ene/2-butene/but-1-ene/1-butene. ✓✓

QUESTION 3

3.1 3.1.1 The chemical process/reaction in which longer chaihydrocarbon/alkane molecules/ are broken down to shorter (more useful) molecules. ✓✓

3.1.2 X = 12 ✓

Y = 2 ✓

Z = 4 ✓

ACCEPT:

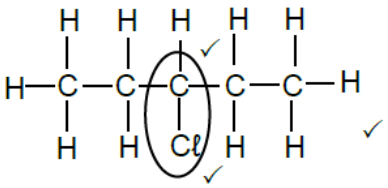
$C_{16}H_{34} \rightarrow C_6H_{14} + C_6H_{12} + 2C_2H_4$

3.1.2 $2C_6H_{14} + 19O_2$ ✓ $\rightarrow 12CO_2 + 14H_2O$ ✓ Bal. ✓

3.2 3.2.1 Compounds with the same molecular formula, but different positions of the side chain / substituents / functional groups on the parent chain. ✓✓

3.2.2 Addition/hydrohalogenation/hydrochlorination. ✓

3.2.3



3.2.4 HCℓ ✓

3.2.5 (Concentrated/ conc.) H_2SO_4 / sulphuric acid / H_3PO_4 / phosphoric acid. ✓

3.2.6 Concentrated strong base. ✓

OR

Concentrated NaOH / KOH / LiOH / sodium hydroxide/ potassium hydroxide/ lithium hydroxide.

OR

Strong base/NaOH/KOH/LiOH/sodium hydroxide/ potassium hydroxide/lithium hydroxide in ethanol.

3.2.7 Elimination. ✓

Dehydrohalogenation/dehydrochlorination.

QUESTION 4

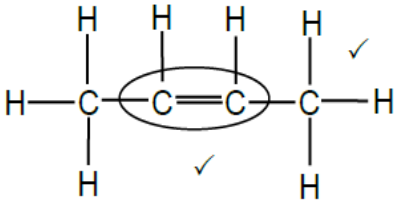
4.1 4.1.1 2-bromo✓butane✓

4.1.2 NaBr/Sodium bromide. ✓

4.1.3 Addition. ✓

Hydrohalogenation/Hydrobromination. ✓

4.1.4

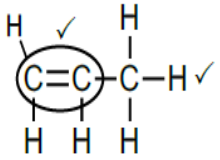


4.1.6 Concentrated strong base. ✓

4.2 4.2.1 The chemical process/reaction in which longer chain hydrocarbon/alkane molecules/ are broken down to shorter (more useful) molecules. ✓✓

4.2.2 Decolourisation/colour fades/becomes lighter in colour/colourless. ✓

4.2.3



4.2.4 X / C_3H_6 / Propene. ✓

• X is unsaturated/has a double bond/is an alkene. ✓

ANY ONE

• X undergoes addition.

OR

Alkenes are more reactive than alkanes/Unsaturated compounds react faster than saturated compounds.

Addition reaction is faster than substitution.

Addition reaction does not need UV/light.

TOPIC 2: RATES AND EXTENT OF REACTIONS

QUESTION 1

1.1 1.1.1 Exothermic. ✓

Lower (potential) energy of the products than reactants. /ΔH < 0/ΔH negative / ΔH = -121,7 kJ/More energy is released than absorbed. ✓

1.1.2 (The number of) particles with sufficient/enough (kinetic) energy (with a catalyst) OR EK ≥ EA (which can undergo effective collisions.) ✓

1.1.3 240,8 – 208,2 ✓ = 32,6 (kJ) ✓

1.2 1.2.1 Decreases. ✓

1.2.2 Remains the same. ✓

1.2.3 Remains the same. ✓

1.3 1.3.1 Concentration (of sulphuric acid/H_2SO_4(aq)). ✓

1.3.2
- More (H_2SO_4) particles per unit volume. ✓
- More effective collisions per unit time./Higher frequency of effective collisions. ✓
- Higher reaction rate. ✓

OR

- Less (H_2SO_4) particles per unit volume. ✓
- Less effective collisions per unit time./Lower frequency of effective collisions. ✓
- Lower reaction rate. ✓

1.3.3

OPTION 1/*OPSIE 1:*

$$\text{Rate/Tempo} = \frac{\Delta V_{H_2}}{\Delta t}$$

$$40 = \frac{\Delta V_{H_2}}{2,6(60)} \quad \checkmark \text{ (a)}$$

$$V(H_2) = 6\,240 \text{ cm}^3$$

$$n(H_2) = \frac{V}{V_m}$$

$$= \frac{6\,240}{27\,000} \quad \checkmark \text{ (b)}$$

$$= 0,23 \text{ mol}$$

$$n(A\ell) = \frac{2}{3} n(H_2)$$

$$n(A\ell) = \frac{2}{3}(0,23) \quad \checkmark \text{ (c)}$$

$$= 0,15 \text{ mol}$$

$$n(A\ell) = \frac{m}{M}$$

$$0,15 = \frac{m}{27} \quad \checkmark \text{ (d)}$$

$$m = 4,05 \text{ g}$$

$$\% \text{ purity/}\textit{suiwerheid} = \frac{4,05}{5}(100) \quad \checkmark \text{ (e)}$$

$$= 81\ \% \ \checkmark \text{ (f)}$$

OPTION 2/*OPSIE 2:*

rate $H_2 = 40 \text{ cm}^3 \cdot \text{s}^{-1}$

$$\textbf{Rate in } n(H_2) = \frac{V}{V_m}$$

$$= \frac{40}{27\,000} \quad \checkmark \text{ (b)}$$

$$= 0,00148 \text{ mol} \cdot \text{s}^{-1}$$

(a) ✓ both/beide

$$\textbf{Rate}(A\ell) = \frac{2}{3} n(H_2)$$

$$= \frac{2}{3}(0,00148) \quad \checkmark \text{ (c)}$$

$$= 9,88 \times 10^{-4} \text{ mol} \cdot \text{s}^{-1}$$

$$n(A\ell) = \frac{m}{M}$$

$$9,88 \times 10^{-4} = \frac{m}{27} \quad \checkmark \text{ (d)}$$

$$m = 0,0267 \text{ g} \cdot \text{s}^{-1}$$

$$\textbf{Rate/Tempo} = \frac{\Delta m_{Al}}{\Delta t}$$

$$0,0267 = \frac{\Delta m_{Al}}{2,6(60)}$$

$$m(A\ell) = 4,16 \text{ g}$$

$$\% \text{ purity/}\textit{suiwerheid} = \frac{4,16}{5}(100) \quad \checkmark \text{ (e)}$$

$$= 83,2\ \% \ \checkmark \text{ (f)}$$

QUESTION 2

2.1 2.1.1 **ANY ONE:**

- Change in concentration of products/reactants per (unit) time. ✓✓
- Change in amount/number of moles/volume/mass of products or reactants per (unit) time.
- Amount/number of moles/volume/mass of products formed/reactants used per (unit) time. ✓✓
- Rate of change in concentration/amount/number of moles/volume/ mass. ✓✓

2.1.2

$$\text{Rate/Tempo} = \frac{\Delta V(H_2)}{\Delta t}$$

$$0{,}033 = \frac{\Delta V(H_2)}{5} \checkmark\textbf{(a)}$$

$$V(H_2) = 0{,}165\ dm^3$$

$$n(H_2) = \frac{V}{V_m}$$

$$= \frac{0{,}165}{24{,}5} \checkmark\textbf{(b)}$$

$$= 6{,}74 \times 10^{-3}\ mol\ (0{,}0067)$$

$$n(A\ell) = \frac{2}{3} n(H_2)$$

$$= \frac{2}{3}(6{,}74 \times 10^{-3}) \checkmark\textbf{(c)}$$

$$= 4{,}49 \times 10^{-3}\ mol\ (0{,}00449)$$

OPTION 1/*OPSIE 1*:

$$n\ (A\ell) = \frac{m}{M}$$

$$4{,}49 \times 10^{-3} = \frac{m(Al)}{27} \checkmark\textbf{(d)}$$

$$m(A\ell) = 0{,}12\ g\ (0{,}121)$$

$$\Delta m(A\ell) = 0{,}5 - 0{,}12 \checkmark\textbf{(e)}$$

$$= 0{,}38\ g \checkmark\textbf{(f)}$$

OPTION 2/*OPSIE 2*:

$$n\ (A\ell) = \frac{m}{M}$$

$$= \frac{0{,}5}{27}$$

$$= 0{,}0185\ mol$$

$$\Delta n(A\ell) = 0{,}0185 - 4{,}49 \times 10^{-3} \checkmark\textbf{(e)}$$

$$= 0{,}014\ mol$$

$$n\ (A\ell) = \frac{m}{M}$$

$$0{,}014 = \frac{m(Al)}{27} \checkmark\textbf{(d)}$$

$$m(A\ell) = 0{,}38\ g \checkmark\textbf{(f)}$$

2.1.3

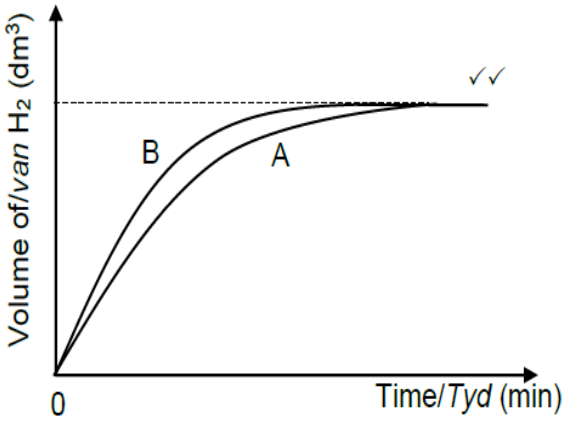
- The surface area/contact area/mass/size of aluminium decreases. ✓
- Less particles exposed. ✓
- Less effective collisions per unit time/second. ✓

OR

Lower frequency of effective collisions. ✓

- Reaction rate decreases./Lower reaction rate./Reaction slows down. ✓

2.1.4



2.1.5 Equal to. ✓

2.2 2.2.1 An increase in temperature. ✓

2.2.2 Curve **Y** has a peak/maximum at a higher kinetic energy./Peak shifted to the right. ✓

OR

The (average) kinetic energy (of the particles) increases./More particles with higher kinetic energy./Larger area with higher kinetic energy. ✓

QUESTION 3

3.1 **ANY ONE:**

- Change in concentration ✓ of products/reactants per (unit) time. ✓
- Change in amount/number of moles/volume/mass of products or reactants per (unit) time.
- Amount/number of moles/volume/mass of products formed/reactants used per (unit) time.
- Rate of change in concentration/amount/number of moles/volume/ mass.

3.2 3.2.1 10 (s) ✓

3.2.2

OPTION 1/*OPSIE 1*:

Rate/*Tempo* $= -\frac{\Delta c(O_2)}{\Delta t}$

$= -\left(\frac{0,15 - 0,27}{10 - 0}\right)$ ✓(a) ✓(b)

$= 0,012\ mol{\cdot}dm^{-3}{\cdot}s^{-1}$

Rate/*Tempo* (O_2) in $mol{\cdot}s^{-1}$
$= cV$
$= (0,012)(3)$ ✓(c)
$= 0,036\ mol{\cdot}s^{-1}$

Rate/*Tempo* (CO_2) = 2 x rate (O_2)
$= 2 \times 0,036$ ✓(d)
$= 0,072\ (mol{\cdot}s^{-1})$ ✓(e)

OPTION 2/*OPSIE 2*:

$\Delta c(O_2) = 0,27 - 0,15$ ✓(a)
$= 0,12\ mol{\cdot}dm^{-3}$

$\Delta n(O_2) = cV$
$= 0,12(3)$ ✓(c)
$= 0,36\ mol$

$\Delta n(CO_2) = 2n(O_2)$ ✓(d)
$= 2(0,36)$
$= 0,72\ mol$

$Rate(CO_2) = \frac{\Delta n}{\Delta t}$
$= \frac{0,72}{10 - 0}$ ✓(b)
$= 0,072\ (mol{\cdot}s^{-1})$ ✓(e)

OPTION 3/*OPSIE 3*:

$n(O_2)_{at\ 0s} = cV$
$= 0,27 \times 3$ ✓(c)
$= 0,81$ mol

$n(O_2)_{at\ 10s} = cV$
$= 0,15 \times 3$
$= 0,45$ mol

$\text{Rate } (O_2) = -\frac{\Delta n}{\Delta t}$
$= -\left(\frac{0,45 - 0,81}{10 - 0}\right)$ ✓(a) ✓(b)
$= 0,036\ mol \cdot s^{-1}$

$\text{Rate } (CO_2) = 2 \times \text{rate } (O_2)$
$= 2 \times 0,036$ ✓(d)
$= 0,072\ (mol \cdot s^{-1})$ ✓(e)

3.2.3 O_2/Oxygen. ✓

3.2.4 Increases. ✓

Higher reaction rate./Concentration of reactants are higher. ✓

ACCEPT: pressure increased.

3.3 3.3.1 Absorption. ✓

3.3.2 Unstable (high energy) transition state from reactants to products. ✓✓

ACCEPT:

Unstable (high energy) transition state between reactants and products. ✓✓

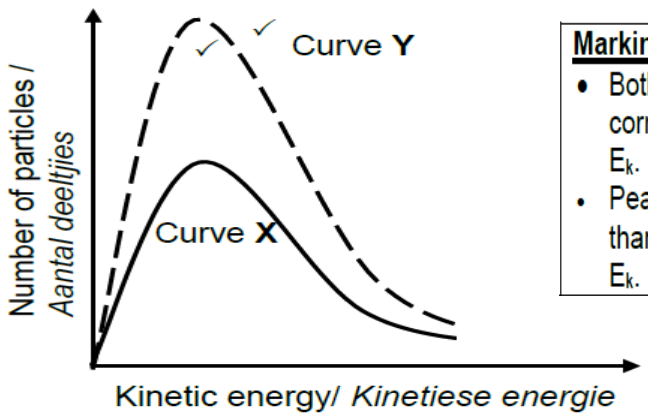
3.3.3
- Catalyst provides an alternative path with lower activation energy / lowers the activation energy. ✓
- More particles have sufficient (kinetic) energy / kinetic energy greater (or equal to) activation energy. ✓
- More effective collisions per unit time/second. ✓

OR

Higher frequency of effective collisions.

3.3.4 Remains the same. ✓

3.3.5



Marking criteria:
- Both curves start at origin and have correct shape with peaks at same E_k. ✓
- Peak of curve Y must be higher than curve X with peaks at same E_k. ✓

QUESTION 4

4.1 **ANY ONE:**

- Change in concentration ✓ of products/reactants per (unit) time. ✓
- Change in amount/number of moles/volume/mass of products or reactants per (unit) time.
- Amount/number of moles/volume/mass of products formed/reactants used per (unit) time.
- Rate of change in concentration/amount/number of moles/volume/ mass. ✓✓

4.2 **ANY ONE:**

Temperature; ✓

(Initial) amount/Mass of magnesium carbonate/Surface area.

4.3 CO_2/gas escapes from the reaction flask. ✓

4.4

Marking criteria:

(a) Mass subtraction ✓

(b) Formula: $n = \frac{m}{M}$ or $V = nV_m$ ✓

(c) Substitute $M = 44\ g{\cdot}mol^{-1}$ in $n(CO_2) = \frac{m}{M}$ with $m(CO_2)$ from (a)✓

(d) Substitute $24,5\ dm^3$ in $V = nV_m$ with $n(CO_2)$ ✓

(e) Substitute V_{CO_2} and 120 in rate formula✓

(f) Final correct answer: $2,92 \times 10^{-3}\ (dm^3{\cdot}s^{-1})$ ✓

Range: $2,08 \times 10^{-3}$ to 3×10^{-3}

Nasienkriteria:

(a) *Aftrek van massas.* ✓

(b) *Formula:* $n = \frac{m}{M}$ *or* $V = nV_m$ ✓

(c) *Vervang* $M = 44\ g{\cdot}mol^{-1}$ *in* $n(CO_2) = \frac{m}{M}$ *met* $m(CO_2)$ van **(a)**✓

(d) *Vervang* $24,5\ dm^3$ *in* $V = nV_m$ *met* $n(CO_2)$✓

(e) *Vervang* V_{CO_2} *en 120 in tempoformule*✓

(f) *Finale korrekte antwoord:* $2,92 \times 10^{-3}\ (dm^3{\cdot}s^{-1})$ ✓

Gebied: $2,08 \times 10^{-3}$ *tot* 3×10^{-3}

$m(CO_2) = 144,5 - 143,87$ ✓ **(a)**

$= 0,63\ g$

$n(CO_2) = \frac{m}{M}$ ✓ **(b)**

$= \frac{0,63}{44}$ ✓ **(c)**

$= 1,43 \times 10^{-2}\ mol$

$V(CO_2) = nV_m$

$= (1,43 \times 10^{-2})(24,5)$ ✓ **(d)**

$= 0,35\ dm^3$

Ave rate/ *gem tempo* $= \frac{\Delta V(CO_2)}{\Delta t}$

$= \frac{0,35 - (0)}{120 - (0)}$ ✓ **(e)**

✓ **(f)**

$= 2,92 \times 10^{-3}\ (dm^3{\cdot}s^{-1})$

4.5 A ✓

- Gradient is least steep/lowest reaction rate/least amount of gas produced in 120 s. ✓
- Lowest concentration of HCℓ(aq). ✓
- Least/Less particles per unit volume. ✓
- Least/Less effective collisions per unit time/second. ✓

OR

Lowest/Lower frequency of effective collisions.

4.6 The same. ✓

The same amount $MgCO_3$ is used in each experiment. ✓

TOPIC 3: CHEMICAL EQUILIBRIUM

QUESTION 1

1.1 1.1.1 When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will cancel/oppose the disturbance. ✓✓

1.1.2 (Mass) decreases. ✓

1.1.3
- Decrease in amount of OH— ions /concentration of OH—- ions, favours the reaction that increases the amount/concentration of OH— ions. ✓ **OR** Acid/ HCℓ/H+ reacts with OH—- ions.
- The forward reaction is favoured **OR** The amount/concentration of the products increases.

1.2 1.2.1 Endothermic. ✓

1.2.2
- With an increase in the temperature the Kc value increases. ✓
- The concentration of the products increases. **OR** Concentration of reactants decreases. **OR** The forward reaction is favoured. ✓
- (According to Le Chatelier's principle) an increase in temperature favours the endothermic reaction. ✓

1.2.3

OPTION 1/*OPSIE 1*:

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

$= \frac{70}{51}$ ✓(a)

	$NH_4HS(s)$	$NH_3(g)$	$H_2S(g)$	
Initial amount (mol) *Aanvanklike hoeveelheid* (mol)	1,37	0	0	
Change (mol) *Verandering (mol)*	x	x	x	✓(b)
Equilibrium amount (mol) *Ewewig hoeveelheid (mol)*	1,37 - x	x	x	
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie ($mol \cdot dm^{-3}$)*		$\frac{x}{3}$	$\frac{x}{3}$	✓(c)

$K_c = [NH_3][H_2S]$ ✓(d)

✓(e) $18 \times 10^{-2} = \left(\frac{x}{3}\right)^2$

$x = 1,27$

$n(NH_4HS)_{eq} = 1,37 - 1,27$ ✓(f)

$= 0,1$ mol

$m(NH_4HS)_{eq} = nM$

$= 0,1 \times 51$ ✓(g)

$= 5,1$ g ✓(h)

No K_c expression, correct substitution
Geen K_c- uitdrukking, korrekte substitusie:
Max./*Maks.* $^7/_8$

Wrong K_c expression/
Verkeerde K_c-uitdrukking: Max./*Maks.* $^6/_8$

OPTION 2/*OPSIE 2*:

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

$= \frac{70}{51}$ ✓(a)

$K_c = [NH_3][H_2S]$ ✓(d)

✓(e) $18 \times 10^{-2} = x^2$

$x = 0,42$

	$NH_4HS(s)$	$NH_3(g)$	$H_2S(g)$	
Initial amount (mol) Aanvanklike *hoeveelheid* (mol)	1,37	0	0	
Change (mol) *Verandering (mol)*	1,26	1,26	1,26	✓(b)
Equilibrium amount (mol) Ewewig hoeveelheid (mol)	✓(f) 0,11	1,26	1,26	
Equilibrium concentration ($mol \cdot dm^{-3}$) Ewewigskonsentrasie ($mol \cdot dm^{-3}$)		0,42	0,42	✓(c)

$m(NH_4HS)_{eq} = nM$

$= 0,11 \times 51$ ✓(g)

$= 5,61\ g$ ✓(h)

OR/*OF*

$m(NH_4HS)_{change} = nM$

$= 1,26 \times 51$ ✓(g)

$= 64,26\ g$

$m(NH_4HS)_{eq} = 70 - 64,26$ ✓(f)

$= 5,74\ g$ ✓(h)

No K_c expression, correct substitution
Geen K_c- uitdrukking, korrekte substitusie:
Max./*Maks.* $^7/_8$

Wrong K_c expression/
Verkeerde K_c-uitdrukking: Max./*Maks.* $^6/_8$

QUESTION 2

2.1 2.1.1 Remains the same. ✓

2.1.2 Decreases. ✓

2.1.3 Remains the same. ✓

2.2 • Decrease in pressure favours the reaction that produces a greater number of moles/amount of gas. ✓

• Forward reaction is favoured. ✓/ [CO] increases AND [CO_2] decreases.

2.3

OPTION 1/*OPSIE 1:*

$\Delta m(C) = 14 - 4,44$ ✓ **(b)**
$= 9,56$ g

$n(CO_2)_{initially} = \frac{m}{M}$
$= \frac{41,2}{44}$ ✓ **(a)**
$= 0,94$ mol (0,936)

$n(C)_{used} = \frac{m}{M}$
$n(C)_{used} = \frac{9,56}{12}$ ✓ **(c)**
$= 0,80$ mol (0,797)

$n(CO_2)_{used} = n(C)$
$= 0,80$ mol (0,797) ✓ **(d)**

$n(CO_2)_{eq} = n(CO_2)_{initially} - n(CO_2)_{used}$
$= 0,94 - 0,80$ ✓ **(e)**
$= 0,14$ mol

$n(CO_2) = \frac{m}{M}$
$0,14 = \frac{m}{44}$
$X = m(CO_2) = 6,16$ (g) ✓ **(f)**

OPTION 2/*OPSIE 2:*

$\Delta m(C) = 14 - 4,44$ ✓ **(b)**
$= 9,56$ g

$n(C)_{used} = \frac{m}{M}$
$n(C)_{used} = \frac{9,56}{12}$ ✓ **(c)**
$= 0,80$ mol (0,797)

$n(CO_2)_{used} = n(C)$
$= 0,80$ mol (0,797) ✓ **(d)**

$n(CO_2) = \frac{m}{M}$
$0,80 = \frac{m}{44}$ ✓ **(a)**
$m(CO_2) = 35,05$ g

$m(CO_2)_{eq} = m(CO_2)_{initially} - m(CO_2)_{used}$
$= 41,2 - 35,05$ ✓ **(e)**
$X = 6,15$ (g) ✓ **(f)**

OPTION 3/*OPSIE 3*:

$n(CO_2)_{initially} = \frac{m}{M}$
$= \frac{41,2}{44}$ ✓ **(a)**
$= 0,94$ mol (0,936)

$n(C)_{used} = \frac{9,56}{12}$ ✓ **(c)**
$= 0,80$ mol (0,797)

	C	CO_2
Ratio/*Verhouding*	1	1
Initial quantity (mol) Aanvangshoeveelheid (mol)	1,17	0,936
Change (mol) *Verandering (mol)*	0,8	0,8 ✓ **(d)**
Quantity at equilibrium (mol)/ *Hoeveelheid by ewewig (mol)*	0,37 ✓ **(b)**	0,14 ✓ **(e)**

$n(CO_2) = 0,139$ mol
$m(CO_2) = 0,139\ (44)$
$X = 6,16$ (g) ✓ **(f)**

2.4

CALCULATIONS USING NUMBER OF MOLES
BEREKENINGE WAT AANTAL MOL GEBRUIK
OPTION 1/*OPSIE 1:*

$$n(CO_2)_{initial} = \frac{m}{M}$$
$$= \frac{41,2}{44}$$
$$= 0,936 \text{ mol}$$

	CO_2	CO	
Ratio/*Verhouding*	1	2	
Initial quantity (mol) Aanvangshoeveelheid (mol)	0,936	0	
Change (mol) *Verandering (mol)*	0,8	1,6	✓ **(a)**
Quantity at equilibrium (mol)/ *Hoeveelheid by ewewig (mol)*	0,14	1,6	
Equilibrium concentration ($mol \cdot dm^{-3}$) Ewewigskonsentrasie ($mol \cdot dm^{-3}$)	0,047	0,53	Divide by/deel deur 3 ✓ **(b)**

$$K_c = \frac{[CO]^2}{[CO_2]}$$ ✓**(c)**
$$= \frac{(0,53)^2}{0,047}$$ ✓**(d)**
$$= 5,98$$ ✓ **(e)**

Wrong K_c expression
Verkeerde K_c-uitdrukking: Max./*Maks.* $^2/_5$
No K_c expression/*Geen K_c- uitdrukking*: $^4/_5$

CALCULATIONS USING CONCENTRATION
BEREKENINGE WAT KONSENTRASIE GEBRUIK
OPTION 2/*OPSIE 2:*

$$c(CO_2) = \frac{m}{MV}$$
$$= \frac{41,2}{(44)(3)}$$
$$= 0,31 \text{ mol} \cdot dm^{-3}$$

Divide by 3 ✓ **(b)**

$$c = \frac{n}{V}$$
$$= \frac{0,8}{3}$$
$$= 0,27 \text{ mol} \cdot dm^{-3} (0,267)$$

	CO_2	CO	
Ratio/*Verhouding*	1	2	
Initial concentration ($mol \cdot dm^{-3}$) *Aanvangskonsentrasie ($mol \cdot dm^{-3}$)*	0,31	0	
Change in concentration ($mol \cdot dm^{-3}$) *Verandering in konsentrasie ($mol \cdot dm^{-3}$)*	0,27	0,54	✓ **(a)**
Equilibrium concentration ($mol \cdot dm^{-3}$) Ewewigskonsentrasie ($mol \cdot dm^{-3}$)	0,04	0,54	

$$K_c = \frac{[CO]^2}{[CO_2]}$$ ✓**(c)**
$$= \frac{(0,54)^2}{0,04}$$ ✓**(d)**
$$= 7,29$$ ✓ **(e)**

Wrong K_c expression
Verkeerde K_c-uitdrukking: Max./*Maks.* $^2/_5$
No K_c expression/*Geen K_c- uitdrukking*: $^4/_5$

OPTION 3/*OPSIE 3*:

$n(CO_2)_{initial} = \frac{m}{M}$

$= \frac{41,2}{44}$

$= 0,936$ mol

$\Delta n(CO_2) = 0,8$ mol

$n(CO_2)_{eqm} = n(CO_2)_{initial} - \Delta n(CO_2)$

$= 0,936 - 0,8$

$= 0,136$ mol

✓ **(a)**

$n(CO)_{formed} = 2\Delta n(CO_2)_{used} = 1,6$ mol

$n(CO)_{eqm} = \Delta n(CO)_{formed} = 1,6$ mol

$[CO_2]_{eqm} = \frac{0,136}{3} = 4,53 \times 10^{-2}$ mol·dm^{-3}

$[CO]_{eqm} = \frac{1,6}{3} = 0,53$ mol·dm^{-3} ✓**(b)**

$K_c = \frac{[CO]^2}{[CO_2]}$ ✓**(c)**

$= \frac{(0,53)^2}{4,53 \times 10^{-2}}$ ✓**(d**

$= 6,2$ ✓ **(e)**

Wrong K_c expression
Verkeerde K_c-uitdrukking: Max./*Maks.* $^2/_5$
No K_c expression/*Geen K_c- uitdrukking*: $^4/_5$

2.5 Y. ✓
2.6 Remains the same. ✓

QUESTION 3

3.1 3.1.1 (The dynamic equilibrium when) the rate of the forward reaction equals the rate of the reverse reaction. ✓✓
OR
The stage in a chemical reaction when the concentrations of the reactants and products remain constant.

3.1.2 X. ✓
3.1.3 Decreased. ✓
3.1.4 The concentrations of (all) the gases decreased./The reverse reaction was favoured. ✓
Accept:
All concentrations decreased.
3.1.5 CO(g)/carbon monoxide. ✓

3.1.4 The concentrations of (all) the gases decreased./The reverse reaction was favoured. ✓

Accept:

All concentrations decreased.

3.1.5 CO(g)/carbon monoxide. ✓

3.1.6 The concentration of **Z** (CO) decreased with a decrease in the concentration of **X** (O_2). ✓

OR

The concentration of **Z** (CO) increased with an increase in the concentration of **X** (O_2).

OR

Z (CO) behaves like **X** (O_2)/Follows the same trend as **X** (O_2).

OR

Z (CO) and **X**(O_2) are both reactants/ **Y** (CO_2) is the product.

OR

The reverse reaction is favoured to increase the number of moles.

3.1.7 Decreased. ✓

3.1.8 • Concentration of products/**Y**/CO_2 increases. ✓

OR

Concentration of reactant/Z/X/CO/O2 decreases.

OR

The forward reaction is favoured.

• The forward reaction is exothermic. ✓

• A decrease in temperature favours the exothermic reaction. ✓

3.2

(x change in amount/ *verandering in hoeveelheid.)*	CO	H_2O	CO_2	H_2
Initial amount (moles) *Aanvanklike hoeveelheid (mol)*	0,6	0,6	0,1	0, 1
Change in amount (moles) *Verandering in hoeveelheid* (mol)	x	x	x	x ✓ **(a)**
Equilibrium amount (moles) *Ewewigshoeveelheid* (mol) ✓ **(b)**	0,6 - x	0,6 - x	0,1 + x	0,1 + x
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie* ($mol \cdot dm^{-3}$)	$\frac{0,6 - x}{2}$	$\frac{0,6 - x}{2}$	$\frac{0,1 + x}{2}$	$\frac{0,1 + x}{2}$

✓ **(c)**

$$K_c = \frac{[CO_2][H_2]}{[CO][H_2O]}$$ ✓ **(d)**

$$4 \text{ ✓ (e)} = \frac{\left(\frac{0,1 + x}{2}\right)\left(\frac{0,1 + x}{2}\right)}{\left(\frac{0,6 - x}{2}\right)\left(\frac{0,6 - x}{2}\right)}$$ ✓ **(f)**

No K_c expression, correct substitution/Geen K_c-uitdrukking, korrekte substitusie: Max./Maks. $^8/_9$
Wrong K_c expression/Verkeerde K_c-uitdrukking: Max./Maks. $^6/_9$

$x = 0,37$

$n(CO)_{eq} = 0,6 - 0,37$ ✓ **(g)**

$= 0,23$ mol

$$n(CO)_{eq} = \frac{m}{M}$$

$$0,23 = \frac{m}{28}$$ ✓ **(h)**

$m(CO)_{eq} = 6,44$ g ✓ **(i)**

$$[CO]_{eq} = \frac{0,6 - x}{2}$$

$$= \frac{0,6 - 0,37}{2}$$ ✓ **(g)**

$= 0,115 \ mol \cdot dm^{-3}$

$n = cV$

$= (0,115)(2)$

$= 0,23$ mol

$$n(CO)_{eq} = \frac{m}{M}$$

$$0,23 = \frac{m}{28}$$ ✓ **(h)**

$m(CO)_{eq} = 6,44$ g ✓ **(i)**

(x equilibrium amount/ *ewewigshoeveelheid.)*	CO	H_2O	CO_2	H_2
Initial amount (moles) *Aanvanklike hoeveelheid (mol)*	0,6	0,6	0,1	0, 1
Change in amount (moles) *Verandering in hoeveelheid* (mol)	-x + 0,6	-x + 0,6	-x + 0,6	-x + 0,6
Equilibrium amount (moles) *Ewewigshoeveelheid* (mol) ✓ **(b)**	x	x	0,7 - x	0,7 - x
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie* ($mol \cdot dm^{-3}$)	$\frac{x}{2}$	$\frac{x}{2}$	$\frac{07 - x}{2}$	$\frac{0,7 - x}{2}$

✓ **(a)**

✓ **(c)**

$$K_c = \frac{[CO_2][H_2]}{[CO][H_2O]}$$ ✓ **(d)**

$$4 \checkmark \textbf{(e)} = \frac{\left(\frac{0,7 - x}{2}\right)\left(\frac{0,7 - x}{2}\right)}{\left(\frac{x}{2}\right)\left(\frac{x}{2}\right)}$$ ✓ **(f)**

$x = 0,23$

$$n(CO)_{eq} = \frac{m}{M}$$

✓ **(g)** $0,23 = \frac{m}{28}$ ✓ **(h)**

$m(CO)_{eq} = 6,44$ g ✓ **(i)**

(x change concentration/ *ewewigskonsentrasie.)*	CO	H_2O	H_2	CO_2
Initial concentration ($mol \cdot dm^{-3}$) Aanvanklike konsentrasie ($mol \cdot dm^{-3}$)	0,3	0,3	0,05	0,05 ✓ **(b)**
Change ($mol \cdot dm^{-3}$) *Verandering* ($mol \cdot dm^{-3}$)	x	x	x	x ✓ **(a)**
Equilibrium concentration ($mol \cdot dm^{-3}$) Ewewigskonsentrasie ($mol \cdot dm^{-3}$)	0,3 - x	0,3 - x	0,05 + x	0,05 + x ✓ **(c)**

$$K_c = \frac{[CO_2][H_2]}{[CO][H_2O]}$$ ✓ **(d)**

✓ **(e)**

$$4 = \frac{(0,05 + x)(0,05 + x)}{(0,3 - x)(0,3 - x)}$$ ✓ **(f)**

$x = 0,18$ (0,183)

$[CO] = 0,3 - 0,18$ ✓ **(g)**

$= 0,12$ $mol \cdot dm^{-3}$

$n(CO)_{eq} = cV$

$= (0,12)(2)$

$= 0,24$ mol

$$n(CO) = \frac{m}{M}$$

$0,24 = \frac{m}{28}$ ✓ **(h)**

$m(CO)_{eqm} = 6,72$ g ✓ **(i)**

(x equilibrium concentration/ ewewigkonsentrasie)	CO	H_2O	H_2	CO_2 ✓ (b)
Initial concentration ($mol \cdot dm^{-3}$) Aanvanklike konsentrasie ($mol \cdot dm^{-3}$)	0,3	0,3	0,05	0,05
Change ($mol \cdot dm^{-3}$) *Verandering ($mol \cdot dm^{-3}$)*	-x + 0,3	-x + 0,3	-x + 0,3	-x + 0,3 ✓ (a)
Equilibrium concentration ($mol \cdot dm^{-3}$) Ewewigskonsentrasie ($mol \cdot dm^{-3}$)	x	x	0,35 - x	0,35 - x ✓ (c)

$$K_c = \frac{[CO_2][H_2]}{[CO][H_2O]}$$ ✓ (d)

✓ (e)

$$4 = \frac{(0,35 - x)(0,35 - x)}{(x)(x)}$$ ✓ (f)

$x = 0,12\ mol \cdot dm^{-3}$

$n(CO)_{eq} = cV$

$= (0,12)(2)$ ✓ (g)

$= 0,24\ mol$

$$n(CO) = \frac{m}{M}$$

$$0,24 = \frac{m}{28}$$ ✓ (h)

$m(CO)_{eqm} = 6,72\ g$ ✓ (i)

(x change in amount/ *verandering in hoeveelheid.)*	CO	H_2O	CO_2	H_2
Initial amount (moles) *Aanvanklike hoeveelheid (mol)*	0,6	0,6	0,1	0, 1 ✓ (a)
Change in amount (moles) *Verandering in hoeveelheid* (mol)	x	x	x	x
Equilibrium amount (moles) *Ewewigshoeveelheid* (mol) ✓ (b)	0,6 + x	0,6 + x	0,1 - x	0,1 - x
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie ($mol \cdot dm^{-3}$)*	$\frac{0,6 + x}{2}$	$\frac{0,6 + x}{2}$	$\frac{0,1 - x}{2}$	$\frac{0,1 - x}{2}$ ✓ (c)

$$K_c = \frac{[CO_2][H_2]}{[CO][H_2O]}$$ ✓ (d)

$$4 \text{ ✓ (e)} = \frac{\left(\frac{0,1 - x}{2}\right)\left(\frac{0,1 - x}{2}\right)}{\left(\frac{0,6 + x}{2}\right)\left(\frac{0,6 + x}{2}\right)}$$ ✓ (f)

$x = -0,37$

$n(CO)_{eq} = 0,6 + (-0,37)$ ✓ (g)

$= 0,23\ mol$

$$n(CO)_{eq} = \frac{m}{M}$$

$$0,23 = \frac{m}{28}$$ ✓ (h)

$m(CO)_{eq} = 6,44\ g$ ✓ (i)

(x equilibrium amount / *ewewigshoeveelheid.)*	CO	H_2O	CO_2	H_2
Initial amount (moles) *Aanvanklike hoeveelheid (mol)*	0,6	0,6	0,1	0, 1
Change in amount (moles) *Verandering in hoeveelheid* (mol)	-0,6 +x	-0,6 +x	-0,6 +x	-0,6 +x
Equilibrium amount (moles) *Ewewigshoeveelheid* (mol) ✓ (b)	x	x	0,7 - x	0,7 - x
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie* ($mol \cdot dm^{-3}$)	$\frac{x}{2}$	$\frac{x}{2}$	$\frac{0,7 - x}{2}$	$\frac{0,7 - x}{2}$

✓ (a)

✓ (c)

$$K_c = \frac{[CO_2][H_2]}{[CO][H_2O]}$$ ✓ (d)

4 ✓ (e) $= \frac{\left(\frac{0,7 - x}{2}\right)\left(\frac{0,7 - x}{2}\right)}{\left(\frac{x}{2}\right)\left(\frac{x}{2}\right)}$ ✓ (f)

$x = 0,23$

$n(CO)_{eq} = \frac{m}{M}$

✓ (g) $0,23 = \frac{m}{28}$ ✓ (h)

$m(CO)_{eq} = 6,44\ g$ ✓ (i)

QUESTION 4

4.1 A reaction where products can be converted back to reactants ✓ (and vice versa).

OR

Both forward and reverse reactions can take place.

OR

A reaction which can take place in both directions.

OR

Products can be converted back to reactants.

4.2 When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will cancel/ oppose the disturbance. ✓✓

4.3 4.3.1 The amount/concentration of $A_2(g)$ was increased./A_2 was added to the container. ✓

4.3.2
- Increase in A_2 /concentration favours the reaction that uses or decreases the amount/concentration of A_2. ✓
- The reverse reaction is favoured. ✓

OR

Amount or concentration of products decreases.

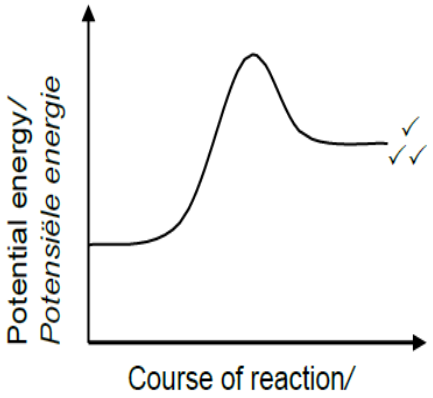
OR

- Amount or concentration of reactants increases.

4.4

OPTION 1/*OPSIE 1:* $K_c = \frac{[A_2][B_2]}{[AB]^2}$ ✓ $= \frac{\left(\frac{8}{4}\right)\left(\frac{2}{4}\right)}{\left(\frac{10}{4}\right)^2}$ ✓ ✓ = 0,16 ✓	**OPTION 2/*OPSIE 2:*** $K_c = \frac{[A_2][B_2]}{[AB]^2}$ ✓ $= \frac{(2)(0,5)}{(2,5)^2}$ ✓ ✓ = 0,16 ✓
OPTION 3/*OPSIE 3:* $K_c = \frac{[A_2][B_2]}{[AB]^2}$ ✓ $= \frac{\left(\frac{4}{4}\right)\left(\frac{4}{4}\right)}{\left(\frac{6}{4}\right)^2}$ ✓ ✓ = 0,44 ✓	**OPTION 4/ *OPSIE 4:*** $K_c = \frac{[A_2][B_2]}{[AB]^2}$ ✓ $= \frac{(1)(1)}{(1,5)^2}$ ✓ ✓ = 0,44 ✓

4.5 4.5.1



Marking criteria/*Nasienkriteria:*

- Both axes correctly labelled and shape of Ep curve. ✓
  Asse korrek benoem en vorm van Ep-kurwe
- Shape of Ep curve for endothermic reaction as shown. ✓✓
  Vorm van kurwe vir endotermiese reaksie soos getoon.

ACCEPT/*AANVAAR:*
Time(s)/*Tyd(s)*

4.5.2
- Less than. ✓
- Amount/concentration of products/B_2/A_2 decreases. ✓✓

OR
- Amount/concentration of reactants/AB increases.

OR
- The reverse reaction is favoured. / Equilibrium (position) shifts to the left.

4.6 Gradients (of all three curves) will be steeper ✓✓ and reach the same equilibrium ✓ values.

OR

Gradients of curve become zero ✓ at same equilibrium ✓ values before 40 s.

OR

The curves are horizontal at same equilibrium values before 40 s / reaches same equilibrium sooner/less than 40 s.

QUESTION 5

5.1 The stage in a chemical reaction when the rate of forward reaction equals the rate of reverse reaction. ✓✓

OR

The stage in a chemical reaction when the concentrations of reactants and products remain constant.

5.2

OPTION 1/*OPSIE 1*

$n(H_2O)_{initial/aanvanklik} = \frac{m}{M} = \frac{36}{18}$ ✓ $= 2$ mol

	H_2O	H_2	CO_2	
Initial amount (moles) *Aanvangs hoeveelheid (mol)*	2			
Change in amount (moles) *Verandering in hoeveelheid* (mol)	0,45	0,45	0,225 ✓	ratio ✓ *verhouding*
Equilibrium amount (moles) *hoeveelheid* (mol)	1,55	0,45	0,225	✓
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie* ($mol \cdot dm^{-3}$)	0,775	0,225	0,1125	Divide by/ Deel deur 2 dm^3 ✓

$$K_c = \frac{[H_2]^2[CO_2]}{[H_2O]^2}$$ ✓

$$= \frac{[0,225]^2[0,1125]}{[0,775]^2}$$ ✓

$= 0,00948$ ✓

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* 7/8
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* 5/8

OPTION 2/*OPSIE 2*

$n(H_2O)_{initial/aanvanklik} = \frac{m}{M} = \frac{36}{18}$ ✓ $= 2$ mol

	H_2O	H_2	CO_2	
Initial concentration ($mol \cdot dm^{-3}$) Aanvangskonsentrasie ($mol \cdot dm^{-3}$)	1			Divide by/ *Deel deur* 2 dm^3 ✓
Change ($mol \cdot dm^{-3}$) ✓ *Verandering* ($mol \cdot dm^{-3}$)	0,225	0,225	0,1125 ✓	ratio ✓ *verhouding*
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie* ($mol \cdot dm^{-3}$)	0,775	0,225	0,1125	

$$K_c = \frac{[H_2]^2[CO_2]}{[H_2O]^2}$$ ✓

$$= \frac{[0,225]^2[0,1125]}{[0,775]^2}$$ ✓

$= 0,00948$ ✓

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* 7/8
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* 5/8

5.3 5.3.1 Steam is used up./Amount of steam decreases./Concentration of steam decreases./Reactants are used up. ✓

5.3.2 Catalyst was added. ✓

5.3.3 Endothermic. ✓

5.3.4
- The forward reaction is favoured. ✓
- Increase in temperature favours the endothermic reaction. ✓

TOPIC 4: ACIDS AND BASES

QUESTION 1

1.1 1.1.1 (It is a) proton/H_3O^+ (ion)/H^+ (ion) donor. ✓✓

1.1.2 HSO_4^+ /hydrogen sulphate ion. ✓

ANY ONE:
- It acts as base in reaction **I** and as acid in reaction **II**. ✓
- Acts as acid and base.

1.1.3 HSO_4^- /Reaction (solution). ✓

Smaller Ka value/weaker acid; ✓

Lower ion concentration/Incompletely ionised. ✓

1.2 1.2.1

OPTION 1/*OPSIE 1*	**OPTION 2/*OPSIE 2***
$pH = -\log[H_3O^+]$ ✓ 1,02 ✓ $= -\log[H_3O^+]$ $[H_3O^+] = 0,0955\ mol{\cdot}dm^{-3}$ ✓ Therefore/*Dus* $[HC\ell] = 0,0955\ mol{\cdot}dm^{-3}$ $(0,096/0,1\ mol{\cdot}dm^{-3})$	$pH = -\log[H_3O^+]$ $[H_3O^+] = 10^{-pH}$ ✓Any one/*Enige* $= 10^{-1,02}$ ✓ $= 0,0955\ mol{\cdot}dm^{-3}$ ✓ Therefore/*Dus* $[HC\ell] = 0,0955\ mol{\cdot}dm^{-3}$ $(0,096/0,1\ mol{\cdot}dm^{-3})$

1.2.2

OPTION 1/*OPSIE 1*

$n(Na_2CO_3) = cV$ ✓
$= 0,075 \times 0,025$ ✓
$= 0,001875\ mol$ $(1,875 \times 10^{-3}/0,002\ mol)$

$n(HC\ell)_{initial/aanvanklik} = cV$
$= 0,096 \times 0,05$ ✓
$= 0,00475\ mol$ $(4,75 \times 10^{-3}/0,005\ mol)$

$n(HC\ell)_{used/gebruik} = 2n(Na_2CO_3)$ ✓
$= 2(0,001875)$
$= 0,0038\ mol$ $(3,75 \times 10^{-3}/0,004\ mol)$

$n(HC\ell)_{excess/oormaat} = 0,00475 - 0,0038$ ✓✓
$= 0,00095 mol$ $(9,5 \times 10^{-4}/1 \times 10^{-3}\ mol)$

$c(HC\ell) = \frac{n}{V}$

$= \frac{0,00095}{0,075}$ ✓

$= 0,013\ mol{\cdot}dm^{-3}$ ✓ $(1,3 \times 10^{-2}\ mol{\cdot}dm^{-3})$

OPTION 2/*OPSIE 2*

$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$ ✓

$\frac{c_a(50)✓}{(0,075)(25)✓} = \frac{2}{1}$ ✓

$c(HCℓ)_{rea} = 0,075\ mol{\cdot}dm^{-3}$

$c(HCℓ)_{excess/oormaat} = 0,0955 - 0,075$ ✓✓

$= 0,0205\ mol{\cdot}dm^{-3}$

$c_1V_1 = c_2V_2$

$(0,0205)(50) = c_2(75)$ ✓

$c_2 = 0,014\ mol{\cdot}dm^{-3}$ ✓

QUESTION 2

2.1 An acid produces hydrogen ions /H^+/hydronium ions/ H_3O^+ in aqueous solution/water. ✓✓

2.2 2.2.1 $(COOH)_2$. ✓

2.2.2 $NaCℓ$. ✓

2.2.3 HCO_3^- ✓

OR NH_3

2.2.4 NaOH ✓✓

OR $Mg(OH)_2$

2.3

OPTION 1/*OPSIE 1:*

$n = cV$

$n_{acid} = (0,11)(0,02364)$ ✓ **(a)**

$= 2,6 \times 10^{-3}$

$n_{base} = (0,26)(0,02)$ ✓ **(b)**

$= 5,2 \times 10^{-3}$ (0,0052)

$\frac{n(H_xY)}{n(NaOH)} = \frac{n_a}{n_b}$

$\frac{2,6 \times 10^{-3}}{5,2 \times 10^{-3}} = \frac{1}{n_b}$

$n_b = 2$

$\therefore x = 2$ ✓ **(c)**

OPTION 2/*OPSIE 2:*

$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$

(a)✓ $\frac{(23,64)(0,11)}{}$

(b)✓ $\frac{}{(20)(0,26)} = \frac{1}{n_b}$

$n_b = 2$

$\therefore x = 2$ ✓ **(c)**

HxY : NaOH

$2,6 \times 10^{-3} : 5,2 \times 10^{-3}$

1 : 2

$H_2Y(aq) + 2NaOH(aq)$ ✓$\rightarrow$ $Na_2Y(aq) + 2H_2O(ℓ)$ ✓ Bal ✓ **(d)**

2.4 pH = -log[H_3O^+] ✓ **(a)**

(b) ✓1,61 = -log[H_3O^+]

[H_3O^+] = $10^{-1,61}$

= 2,45 x 10^{-2} mol·dm^{-3} (0,0245)

$n(HCl)_{unused}$ = $n(H_3O^+)$ = cV

= $(2,45 \times 10^{-2})(0,2)$ ✓ **(c)**

= 4,9 x 10^{-3} mol (0,0049)

$n(HCl)_{initial}$ = cV

= (0,15)(0,2) ✓ **(d)**

= 3 x 10^{-2} mol (0,03)

$n(HCl)_{used}$ = 3 x 10^{-2} – 4,9 x 10^{-3} ✓ **(e)**

= 2,51 x 10^{-2} mol (0,0251)

Reaction ratio $nCaCO_3$: $nHCl$ = 1:2 ✓ **(f)**

$n(CaCO_3)$ = ½(2,51 x 10^{-2}) = 1,25 x 10^{-2} mol

$n(CaCO_3) = \frac{m}{M}$

$1,25 \times 10^{-2} = \frac{m}{100}$ ✓ **(g)**

$m(CaCO_3)$ = 1,25 g

m of impurity in the sample = 1,5 – 1,25 ✓ **(h)**

= 0,25 g ✓ **(i)**

QUESTION 3

3.1 A strong base (ionises) dissociates completely in water to form a high concentration of OH- ions. ✓✓

ACCEPT:

A strong base (ionises) dissociates completely ✓ in water. ✓

3.2 3.2.1 $n(Ba(OH)_2)$ = cV✓

$n(Ba(OH)_2)$ = (0,15)(0,02) ✓

$n(Ba(OH)_2)$ = 0,003 mol ✓

3.2.2 $nHNO_{3\ reacted} = 2nBa(OH)_2$

$nHNO_{3\ reacted}$ = 2(0,003) ✓ (a)

$nHNO_{3\ reacted}$ = 0,006 mol

OPTION 1/ *OPSIE 1*

$n(H_3O^+) = n(HNO_3)$

= 0,006 mol

$[H_3O^+] = \frac{n}{V}$

$= \frac{0,006}{0,025}$ ✓**(b)**

= 0,24 mol·dm^{-3}

OPTION 2/*OPSIE 2*

$[HNO_3] = \frac{n}{V}$

$= \frac{0,006}{0,025}$ ✓**(b)**

= 0,24 mol·dm^{-3}

$[H_3O^+] = [HNO_3]$

= 0,24 mol·dm^{-3}

pH = -log[H_3O^+] ✓**(c)**

= -log(0,24) ✓**(d)**

= 0,62 ✓**(e)**

3.3

OPTION 1/ *OPSIE 1*

$n(HNO_3)_{ini} = cV$

$= (0,4)(0,025)$ ✓ **(a)**

$= 0,01$ mol

$n(HNO_3)_{react} = n(HNO_3)_{ini} - n(HNO_3)_{excess}$

$= 0,01 - 0,006$ ✓✓ **(b)**

$= 0,004$ mol

$n(MCO_3) = ½n(HNO_3)$

$= ½(0,004)$ ✓**(c)**

$= 0,002$ mol

$m(MCO_3) = \frac{85}{100} \times 0,198$ ✓**(d)**

$= 0,168$ g

$n(MCO_3) = \frac{m}{M}$

$0,002 = \frac{0,168}{M}$ ✓**(e)**

$M(MCO_3) = 84$ g·mol^{-1}

Molar mass (M) = 84 - 60 ✓**(f)**

$= 24$ g·mol^{-1}

Therefore metal M is Mg ✓**(g)**

OPTION 2/ *OPSIE 2*

$[HNO_3]_{reacted} = [HNO_3]_{initial} - [HNO_3]_{excess}$

$= 0,4 - 0,24$ ✓✓ **(b)**

$= 0,16$ mol·dm^{-3}

In 1 dm^3 : 0,16 mol

In 0,025 dm^3 : 0,004 mol ✓ **(a)**

$n(MCO_3) = ½n(HNO_3)$

$= ½(0,004)$ ✓**(c)**

$= 0,002$ mol

$m(MCO_3) = \frac{85}{100} \times 0,198$ ✓**(d)**

$= 0,168$ g

$n(MCO_3) = \frac{m}{M}$

$0,002 = \frac{0,168}{M}$ ✓**(e)**

$M(MCO_3) = 84$ g·mol^{-1}

Molar mass (M) = 84 - 60 ✓**(f)**

$= 24$ g·mol^{-1}

Therefore, metal M is Mg ✓**(g)**

QUESTION 4

4.1 4.1.1

OPTION 1/*OPSIE 1:*

$c = \frac{m}{MV}$ ✓

$= \frac{10}{(106)(0,7)}$ ✓

$= 0,13$ mol·dm^{-3} ✓

OPTION 2/*OPSIE 2:*

$n = \frac{m}{M}$ — Any one/*Enige een* ✓

$= \frac{10}{106}$ ✓

$= 0,09$

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

$= \frac{0,09}{0,7}$

$= 0,13$ mol·dm^{-3} ✓

4.1.2 Greater than. ✓

4.1.3 $CO_3^{2-}(aq) + H_2O(\ell)$ ✓ $\rightleftharpoons HCO_3^-(aq) + OH^-(aq)$ ✓

OR

$CO_3^{2-}(aq) + 2H_2O(\ell)$ ✓ $\rightleftharpoons H_2CO_3(aq) + 2OH^-(aq)$ ✓

OR

$Na_2CO_3(aq) + H_2O(\ell)$ ✓ $\rightleftharpoons NaHCO_3(aq) + NaOH(aq)$ ✓

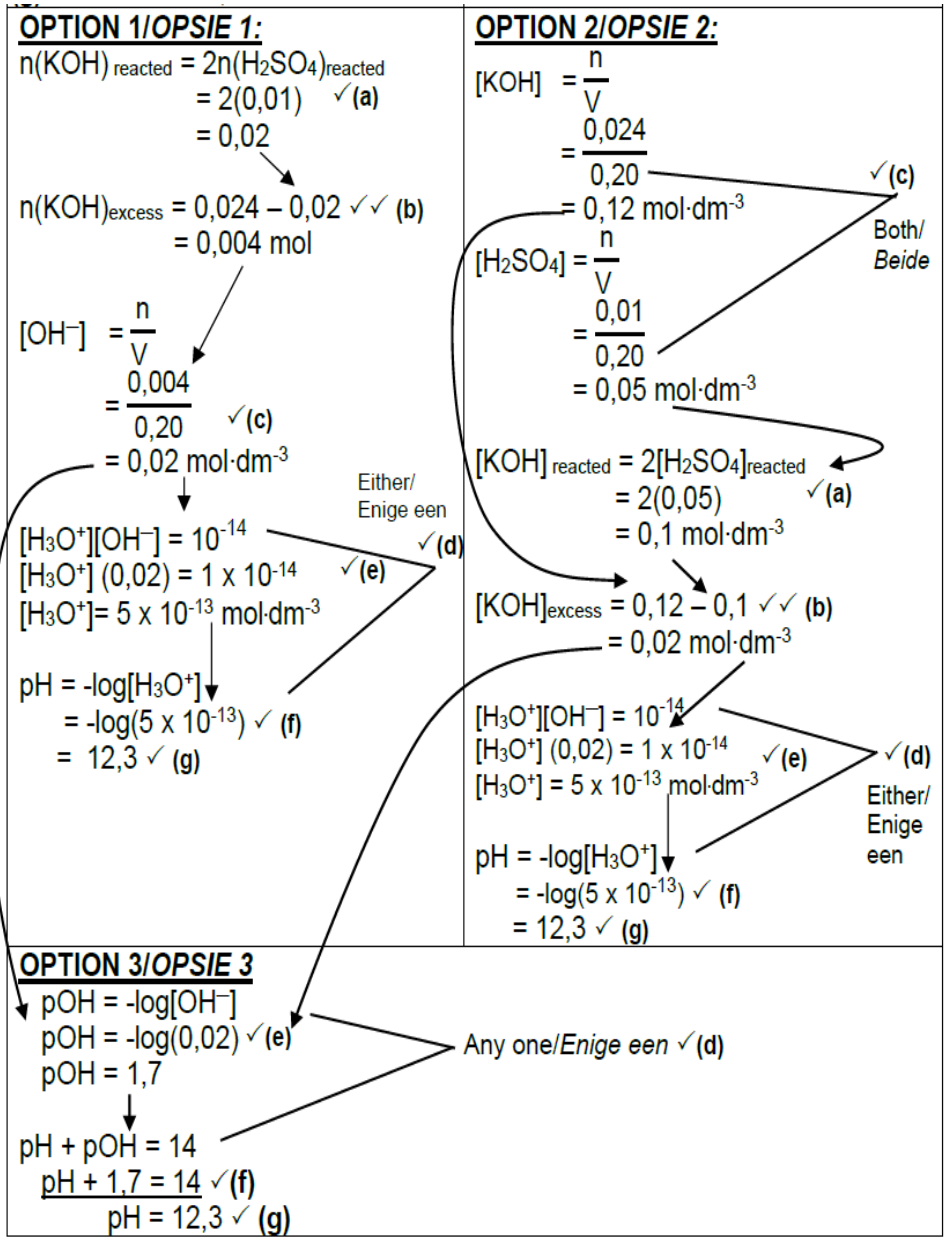
OR

$Na_2CO_3(aq) + 2H_2O(\ell)$ ✓ $\rightleftharpoons H_2CO_3(aq) + 2NaOH(aq)$ ✓

4.1.4 P ✓

(Titration of) weak base and a strong acid./The equivalence point is lower than pH 7. ✓

4.2 4.2.1 Dilute acid contains small amount/number of moles of acid in proportion to the volume of water. ✓



QUESTION 5

5.1 5.1.1 $H_2PO_4^-$ ✓

K_a of $H_2PO_4^-$ greater/higher than K_a of HPO_4^{2-} ✓

Accept: K_a of $H_2PO_4^-$ greater.

5.1.2 HPO_4^{2-} ✓

5.1.3 $H_2PO_4^-$ **OR** HPO_4^{2-} ✓

5.1.4 Basic. ✓

5.1.5 $HPO_4^{2-}(aq) + H_2O(\ell)$ ✓ $\rightleftharpoons H_2PO_4^-(aq) + OH^-(aq)$ ✓ Bal. ✓

OR

$HPO_4^{2-}(aq) + 2H_2O(\ell) \rightleftharpoons H_3PO_4\ (aq) + 2OH^-(aq)$

ACCEPT:

$Na_2HPO_4(aq) + H_2O(\ell) \rightleftharpoons NaH_2PO_4(aq) + NaOH(aq)$

$Na_2HPO_4(aq) + H_2O(\ell) \rightleftharpoons H_2PO_4^-(aq) + 2Na^+(aq) + OH^-(aq)$

$Na_2HPO_4(aq) + H_2O(\ell) \rightleftharpoons NaH_2PO_4(aq) + NaOH(aq)$

$Na_2HPO_4(aq) + 2H_2O(\ell) \rightleftharpoons H_3PO_4(aq) + 2Na^+(aq) + 2OH^-(aq)$

$Na_2HPO_4(aq) + 2H_2O(\ell) \rightleftharpoons H_3PO_4(aq) + 2NaOH\ (aq)$

5.2 5.2.1

OPTION 1/*OPSIE 1*

$pH = -\log[H_3O^+]$

12,62 ✓**(b)** $= -\log[H_3O^+]$ **OR/*OF*** $[H_3O^+] = 10^{-12,62}$

$[H_3O^+] = 2,4 \times 10^{-13}$

Any one/*Enige een* ✓**(a)**

$[H_3O^+][OH^-] = 10^{-14}$

✓**(c)**

$(2,4 \times 10^{-13})[OH^-] = 1 \times 10^{-14}$

$[OH^-] = 0,0417\ mol{\cdot}dm^{-3}$ ✓**(d)** (0,04)

OPTION 2/*OPSIE 2*

$pH + pOH = 14$

✓**(b)** $12,62 + pOH = 14$

$pOH = 1,38$

Any one/*Enige een* ✓**(a)**

$pOH = -\log[OH^-]$

1,38 ✓**(c)** $= -\log[OH^-]$

$[OH^-] = 0,042\ mol{\cdot}dm^{-3}$ ✓**(d)** (0,04)

5.2.2

OPTION 1/*OPSIE 1*

$nHCl = cV$

$= (0,2)(0,015)$ ✓(a)

$= 3 \times 10^{-3}$ mol

$nOH^- = nHCl$ ✓(b)

$= 3 \times 10^{-3}$ mol

$nOH^-_{final} = cV$

$= (0,0417)(0,04)$ ✓(c)

$= 1,67 \times 10^{-3}$ mol

$nOH^-_{ini} = 3 \times 10^{-3} + 1,67 \times 10^{-3}$ ✓✓ (d)

$= 4,67 \times 10^{-3}$ mol

$nBa(OH)_2 = \frac{1}{2} nOH^-_{ini}$

$= \frac{1}{2}(4,67 \times 10^{-3})$ ✓(e)

$= 2,33 \times 10^{-3}$ mol in 25 cm^3

In 100 cm^3 $= (4)(2,33 \times 10^{-3})$ ✓(f)

$= 9,34 \times 10^{-3}$ mol ✓(g)

OPTION 2/*OPSIE 2*

$nHCl = cV$

$= (0,2)(0,015)$ ✓(a)

$= 3 \times 10^{-3}$ mol

$nBa(OH)_2 = \frac{1}{2} nHCl$

$= \frac{1}{2}(3 \times 10^{-3})$ ✓(b)

$= 1,5 \times 10^{-3}$ mol

$nOH^-_{final} = cV$

$= (0,0417)(0,04)$ ✓(c)

$= 1,67 \times 10^{-3}$ mol

$nBa(OH)_2 = \frac{1}{2} nOH^-_{ini}$

$= \frac{1}{2}(1,67 \times 10^{-3})$ ✓(e)

$= 8,33 \times 10^{-4}$ mol

$nBa(OH)_{2\,ini} = 1,5 \times 10^{-3} + 8,33 \times 10^{-4}$ ✓✓ (d)

$= 2,33 \times 10^{-3}$ mol in 25 cm^3

In 100 cm^3 $= (4)(2,33 \times 10^{-3})$ ✓(f)

$= 9,34 \times 10^{-3}$ mol ✓(g)

OPTION 3/*OPSIE 3:*

$nHCl = cV$

$= (0,2)(0,015)$ ✓(a)

$= 3 \times 10^{-3}$ mol

$nBa(OH)_2 = \frac{1}{2} nHCl$

$= \frac{1}{2}(3 \times 10^{-3})$ ✓(b)

$= 1,5 \times 10^{-3}$ mol

$cBa(OH)_2 = \frac{1}{2} cOH^-_{final}$ ✓(e)

$= \frac{1}{2}(0,0417)$

$= 0,02085$ mol·dm^{-3}

$nBa(OH)_2 = cV$

$= 0,02085 \times 0,04$ ✓(c)

$= 8,34 \times 10^{-4}$ mol

$nBa(OH)_{2\,ini} = 1,5 \times 10^{-3} + 8,34 \times 10^{-4}$ ✓✓ (d)

$= 2,34 \times 10^{-3}$ mol in 25 cm^3

In 100 cm^3 $= (4)(2,34 \times 10^{-3})$ ✓(f)

$= 9,36 \times 10^{-3}$ mol ✓(g)

✓(g) in all options/*in alle opsies*:

$nBa(OH)_2$ in 25 cm^3 $= cV$

$2,33 \times 10^{-3}$ mol $= c(0,025)$

$cBa(OH)_2$ in 25 cm^3 $= 0,0936$ mol·dm^{-3}

$nBa(OH)_2$ in 100 cm^3 $= cV$

$= (0,0936)(0,1)$

$= 0,0936$ mol

TOPIC 5: ELECTROCHEMICAL REACTIONS

A. GALVANIC CELLS

QUESTION 1

1.1 **ANY ONE:**

- A substance whose (aqueous) solution contains ions. ✓✓
- Substance that dissolves in water to give a solution that conducts electricity (through movement of ions).

OR

- A substance that dissociates to form ions in water/in molten state.

1.2 $A\ell^{3+}$/Aluminium ion. ✓

$A\ell$ is oxidised **OR** $A\ell$ is a stronger reducing agent.

✓

1.3 $A\ell(s) \mid A\ell^{3+}(aq)$ ✓ $\| Zn^{2+}(aq) \mid Zn(s)$ ✓

OR

$A\ell(s) \mid A\ell^{3+}$ $(1\ mol{\cdot}dm^{-3}) \| Zn^{2+}(aq)$ $(1\ mol{\cdot}dm^{-3}) \mid Zn(s)$

ACCEPT

$A\ell \mid A\ell^{3+} \| Zn^{2+} \mid Zn$

1.4

OPTION 1/*OPSIE 1:*

$n(A\ell^{3+}) = cV$

$= (1)(0,25)$ ✓(a)

$= 0,25\ mol$

$n A\ell_2(SO_4)_3 = \frac{1}{2} n(A\ell^{3+})$

$= \frac{1}{2}(0,25)$ ✓(b)

$= 0,125\ mol$

$n A\ell_2(SO_4)_3 = \frac{m}{M}$

$0,125 = \frac{m}{342}$ ✓(c)

$m = 42,75\ g$ ✓(d)

OPTION 2/*OPSIE 2:*

$c = \frac{m}{VM}$

✓(a) $1 = \frac{m}{(0,25)(342)}$ ✓(c)

$m = 85,5\ g$

$Al_2(SO_4)_3 \rightarrow 2\ mol{\cdot}dm^{-3}\ Al^{3+}$

$m(Al_2(SO_4)_3) = \frac{1}{2}(85,5)$ ✓(b)

$= 42,75\ g$ ✓(d)

QUESTION 2

2.1 H^+/H_3O^+ ions/hydrogen ions/hydronium ions/oxonium ions. ✓

2.2 0,77 V ✓

2.3 A ✓

2.4 H_2 is a stronger reducing agent✓ than Fe^{2+}/Fe(II) ions ✓ and will reduce Fe^{3+}/Fe(III) ions ✓ (to Fe^{2+}/Fe(II) ions).

OR

Fe^{2+}-ion is a weaker reducing agent than H_2✓ and therefore Fe^{3+}/Fe(III) ions (to Fe^{2+}/Fe(II) ions) will be reduced.

2.5 2.5.1 Pt/Platinum. ✓

2.5.2 $H_2 \rightarrow 2H^+ + 2e^-$ ✓✓

✓

2.5.3 Pt(s) | H2(g) | H+(aq) ✓ || Fe3+(aq),Fe2+(aq) | Pt(s) ✓

OR

Pt(s) | H_2(g) | H+(1 mol·dm^{-3}) || Fe^{3+}(1 mol·dm^{-3}),Fe^{2+}(1 mol·dm^{-3}) | Pt(s)

ACCEPT:

Pt | H_2 | H^+ || Fe^{3+},Fe^{2+} | Pt

2.6 The reaction reaches equilibrium/no charges/electrons flow. ✓

QUESTION 3

3.1 3.1.1 The oxidation number of H changes from +1 to 0 ✓AND the oxidation number of Mg changes from 0 to +2. ✓

OR

$Mg^0 \rightarrow Mg^{2+}$ Oxidation number increases.

$H^+ \rightarrow H_20$ Oxidation number decreases.

3.1.2 H^+/HCℓ. ✓

3.1.3 Cu/copper is a weaker reducing agent ✓ than hydrogen/H_2 ✓ (and will not reduce H^+/hydrogen ion to H_2).

OR

Cu/copper is too weak a reducing agent ✓ to reduce H^+/hydrogen ion (to H_2). ✓

3.1.4 Yes. ✓

NO_3^-/Nitrate ion/Nitric acid is a stronger oxidising agent ✓ than Cu^{2+}/copper (II) ion ✓ (therefore Cu/copper will be oxidised to Cu^{2+} /copper (II) ion).

3.2 3.2.1 $Pb(s) + 2Fe^{3+}(aq)$ ✓→ $Pb^{2+}(aq) + 2Fe^{2+}(aq)$ ✓ Bal. ✓

OR:

$Pb + 2Fe^{3+}$✓→ $Pb^{2+} + 2Fe^{2+}$ ✓ Bal. ✓

3.2.2 Increases. ✓

QUESTION 4

4.1 Aluminium/Aℓ ✓

4.2 0,325 (mol·dm^{-3}) ✓✓

Range: 0,32 – 0,33 (mol·dm^{-3})

4.3 Decreases. ✓

M^{2+} is reduced/ M^{2+} used up/M^{2+} is the oxidising agent. ✓

4.4 M. ✓

4.5

OPTION 1/*OPTION 1*	**NOTE/*LET WEL***
$E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ ✓ 2 ✓✓= $E^{\theta}_{cathode}$ – (-1,66) ✓ $E^{\theta}_{cathode}$ = 0,34 (V) ✓ M is copper/Cu/*koper* ✓	• Accept any other correct formula from the data sheet. */Aanvaar enige ander korrekte formule vanaf gegewensblad.* • Any other formula using unconventional abbreviations, e.g. $E°_{cell} = E°_{OA} - E°_{RA}$ followed by correct substitutions:/*Enige ander formule wat onkonvensionele afkortings gebruik, bv.* $E°_{sel} = E°_{OM} - E°_{RM}$ *gevolg deur korrekte vervangings* $^5/_6$

OPTION 2/*OPSIE 2*

$M^{2+}(aq) + 2e^- \rightarrow M(aq)$	E = +x V
✓ $A\ell(s) \rightarrow A\ell^{3+}(aq) + 3e^-$	E = +1,66 V ✓
$2A\ell(s) + 3M^{2+}(aq) \rightarrow 2A\ell^{3+}(aq) + 3M(s)$	E = 2,00 (V) ✓✓

x = 0,34 (V) ✓

M is copper/Cu/*koper* ✓

4.6 4.6.1 Magnesium/Mg. ✓

4.6.2 $A\ell^{3+}$ is a stronger oxidising agent than Mg^{2+}✓, therefore, Mg will be oxidised ✓(to Mg^{2+}). ✓

Mg^{2+} is a weaker oxidising agent than $A\ell^{3+}$✓, therefore, Mg will be oxidised ✓(to Mg^{2+}).

B. ELECTROLYTIC CELL

QUESTION 1

1.1 **ANY ONE:**

- The chemical process in which electrical energy is converted to chemical energy. ✓✓
- The use of electrical energy to produce a chemical change.
- Decomposition of an ionic compound by means of electrical energy.
- The process during which an electric current passes through a solution/ionic liquid/molten ionic compound.

1.2 1.2.1 X ✓

1.2.2 $2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ ✓✓

1.2.3 X to Y. ✓

1.2.4 $2H_2O(\ell) + 2C\ell^-(aq)$ ✓ $\rightarrow C\ell_2(g) + H_2(g) + 2OH^-(aq)$ ✓ Bal ✓

OR

$2H_2O(\ell) + 2NaC\ell(aq) \rightarrow C\ell_2(g) + H_2(g) + 2NaOH(aq)$

1.3 Increases. ✓

1.4 Solution becomes basic / alkaline **OR** NaOH / OH^- (ions) form. ✓

QUESTION 2

2.1 **ANY ONE:**

ANY ONE:

- The chemical process in which electrical energy is converted to chemical energy. ✓✓
- The use of electrical energy to produce a chemical change.
- The process during which an electric current passes through a solution / molten ionic compound.

2.2 2.2.1 $Cr^{3+}(aq) + 3e^- \rightarrow Cr$ ✓✓

2.2.2 $q = I\Delta t$ ✓

$q = (2,5)(10 \times 60 \times 60)$ ✓

$q = 9 \times 10^4$ C ✓ (90 000 C)

2.2.3

OPTION 1/*OPSIE 1*

$n = \frac{Q}{e} / \frac{Q}{q_e}$

$= \frac{9 \times 10^4}{1,6 \times 10^{-19}}$ ✓(a)

$= 5,63 \times 10^{23}$ electrons

$N(\text{Cr atoms}) = \frac{5,63 \times 10^{23}}{3}$ ✓(b)

$= 1,88 \times 10^{23}$

$n(Cr) = \frac{N}{N_A}$

$= \frac{1,88 \times 10^{23}}{6,02 \times 10^{23}}$ ✓(c)

$= 0,31$ mol

$n(Cr) = \frac{m}{M}$

$m(Cr) = 0,31 \times 52$ ✓(d)

$= 16,12$ g

$m(X) = 16,12 + 2,2$ ✓(e)

$= 18,32$ (g) ✓(f)

OPTION 2/*OPSIE 2*

$n(Cr) = \frac{9 \times 10^4}{3 \times 96\,500}$ ✓✓(a & c)

✓(b)

$= 0,31$ mol

$m(Cr) = 0,31 \times 52$ ✓(d)

$= 16,12$ g

$m(X) = 16,12 + 2,2$ ✓(e)

$= 18,32$ (g) ✓(f)

QUESTION 3

3.1 Electrolytic (cell). ✓

Cells have a battery/DC power source/ /Electrical energy is converted to chemical energy. ✓

3.2 3.2.1 $2C\ell^- \rightarrow C\ell_2 + 2e^-$ ✓✓

3.2.2 $A\ell^{3+} + 3e^- \rightarrow A\ell$ ✓✓

3.2.3 Cu/copper. ✓

3.3 **ANY ONE:**

- The electrode/carbon/C reacts with oxygen. ✓
- $C + O_2 \rightarrow CO_2$
- Oxidation takes place./Electrons are lost.
- Oxygen corrodes the carbon electrode.

QUESTION 4

4.1 Electrical to chemical (energy). ✓

4.2 P ✓

4.3 $Ag^+ + e^- \rightarrow Ag$ ✓✓

4.4

OPTION 1/*OPSIE 1:*

$n(Ag) = \frac{m}{M}$

$= \frac{3,25}{108}$ ✓(a)

$= 0,03$ mol

$n(e^-) = \frac{N}{N_A}$

(c) ✓ $0,03 = \frac{N}{6,02 \times 10^{23}}$ ✓(b)

$N\ e^- = 1,81 \times 10^{22}$

$N\ e^- = \frac{Q}{e}$ **OF/OR** $\frac{Q}{q_e}$

$1,81 \times 10^{22} = \frac{Q}{1,6 \times 10^{-19}}$

$Q = 2\ 889,6$ C

$I = \frac{Q}{\Delta t}$

$= \frac{2\ 889,6}{30(60)}$ ✓(d)

$= 1,61$ A ✓(e)

OPTION 2/*OPSIE 2:*

$n(Ag) = \frac{m}{M}$

$= \frac{3,25}{108}$ ✓(a)

$= 0,03$ mol $= n\ e^-$

✓(b)

$Q = 0,03 \times 96\ 500$ ✓(c)

$= 2\ 895$ C

$I = \frac{Q}{\Delta t}$

$= \frac{2\ 895}{30(60)}$ ✓(d)

$= 1,61$ A ✓(e)

QUESTION 5

5.1 Electrolytic. ✓

5.2 5.2.1 Increases. ✓

5.2.2 Decrease. ✓

- More copper (II) ions/Cu^{2+} are reduced than formed./ Only copper (II) ions/Cu^{2+} are reduced. ✓
- Copper (II) ion/Cu^{2+} is a stronger oxidising agent than the zinc (II) ion/Zn^{2+} ✓

  OR

  Zinc (II) ion/Zn^{2+} is a weaker oxidising agent than the copper (II) ion/Cu^{2+}.

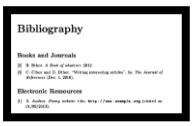
5.2.3

$n(Zn^{2+}) = n(Cu^{2+})$
$= 0,05$ mol ✓**(a)**

$m(Zn) = nM$ ✓**(b)**
$= (0,05)(65)$ ✓**(c)**
$= 3,25$ g Zn from R

$0,15 - 0,05$ ✓**(d)** $= 0,1$ mol Cu
$m(Cu) = nM$
$= 0,1(63,5)$ ✓**(e)**
$= 6,35$ g Cu from R

Change in mass $= 6,35 + 3,25$
$= 9,6$ g ✓**(f)** (decrease in mass)


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Books and Journals

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