Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2012

Marking Scheme

Chemistry

Higher Level

Introduction

In considering the marking scheme the following should be noted.

1. In many cases only key phrases are given which contain the information and ideas that must appear in the candidate's answer in order to merit the assigned marks.

2. The descriptions, methods and definitions in the scheme are not exhaustive and alternative valid answers are acceptable.

3. The detail required in any answer is determined by the context and the manner in which the question is asked, and by the number of marks assigned to the answer in the examination paper, and in any instance, therefore, may vary from year to year.

4. The bold text indicates the essential points required in the candidate's answer. A double solidus (//) separates points for which separate marks are allocated in a part of the question. Words, expressions or statements separated by a solidus (/) are alternatives which are equally acceptable for a particular point. A word or phrase in bold, given in brackets, is an acceptable alternative to the preceding word or phrase. Note, however, that words, expressions or phrases must be correctly used in context and not contradicted, and where there is evidence of incorrect use or contradiction, the marks may not be awarded. Cancellation mat apply when a candidate gives a list of correct and incorrect answers.

5. In general names and formulas of elements and compounds are equally acceptable except in cases where either the name or the formula is specifically asked for in the question. However, in some cases where the name is asked for, the formula may be accepted as an alternative.

6. There is a deduction of one mark for each arithmetical slip made by a candidate in a calculation.

Outline Marking Scheme

Eight questions to be answered in all. These *must* include at **least two** questions from **Section A**.

Section A

Question 1 (a) EXPLAIN: 3 + 2; (b) DESCR: 4 × 3, CALC: 6; (c) (i) 3, (ii) 3; (d) NAME: 3, CHANGE: 2 × 3; (e) CALC: (i) 9, (ii) 3.

Question 2 (a) DRAW:3, 3, 3, 2; (b) (i) 3, (ii) 3, (iii) 3; (c) TEST: 3, 2 × 3; (d) WRITE: 6; (e) NUMBER: 15.

Question 3 (a) GIVE: 5; (b) (i) 3 × 3, (ii) 6; (c) EXPL: 2 × 3; (d) MOL: 9, M_r: 6; (e) WHY: 3, WHAT: 6.

Section B

Question 4

Eight highest scoring items to count. One additional mark to be added to the first two items for which the highest marks are obtained.

(a) STATE: 2 × 3; (b) WRITE: 6; (c) DEFINE: 2 × 3; (d) DISTING: 2 × 3; (e) BALANCE: 6; (f) STATE: 2 × 3; (g) WHY: 6; (h) NAME: (i) 3 (ii) 3; (i) DEFINE: 6; (j) WHAT: 2 × 3; (k) **A**: 2 × 3; **B**: 2 × 3.

Question 5 (a) WRITE: 3 + 2; (b) DEFINE: 6, STATE: 3, EXPLAIN: 3; (c) REASON: 3; (d) (i) STATE: 3, WHAT: 3, (ii) FROM: 2 × 3, GIVE: 3, (iii) SHAPE: 3, EXPL: 3; (e) WOULD: 2 × 3, JUSTIFY: 3.

Question 6 (a) NAME: 3 + 3 + 2;(b) HYDROCARBON: 3, STRUCTURE: 3, PRODUCT: 3, OCTANE NUMBER: 3; (c) EXPLAIN: 3; NAME: 3, STATE: 3; (d) (i) DEFINE: 2 × 3, NAME: 3; (e) CALCULATE: 12.

Question 7 (a) CAUSE: 3, WASTE: 3, DE-ION: 3 + 2; (b) PURPOSE: 5 × 3, STATE: 2 × 3; (c) CONCERN: 3, NAME: 6, EXPLAIN: 3; (d) TEST: 2 × 3.

Question 8 (a) GIVE: (i) 5 (ii) 3; (b) EXPLAIN: 2 × 3, WHAT: 2 × 3, IDENTIFY: 6; (c) CPD: 3; (d) NAME: 2 × 3; (e) DESC: 3 × 3, WHY: 3; (f) WHICH: 3.

Question 9 (a) DEFINE: 5, PLOT: 4 × 3, USE: 6, MARK: 2 × 3, JUSTIFY: 3; (b) TYPE: 3, COLOURS: 6, EXPLAIN: 3 × 3.

Question 10

(a) (i) 4 + 3, (ii) MECHANISM: 4 × 3, STATE: 6.

(b) DEFINE, WHAT: 4 + 3, STATE, EXPLAIN: 2 × 3, CALC: (i) 6, (ii) 6.

(c) (i) WHAT: 4, (ii) HOW: 6, (iii) MASS: 9, (iv) LOSS: 6.

Question 11

(a) (i) WHAT: 4, (ii) DESC: 2 × 3, (iii) EXPL: 2 × 3, (iv) SOME, SMALL: 2 × 3, (v) DRAW: 3.

(b) WRITE: 6, CALC: 12, STATE, EXPLAIN: 4 + 3.

(c) **A** (i) 4× 3, (ii) 3× 3, (iii) 4.

B (i) 4, (ii) 2 × 3, (iii) 2 × 3, (iv) 3× 3.

QUESTION 1

(a) EXPLAIN: **can be dissolved (used) to make up a solution of exact (known) concentration / no need to standardise by titration (can be made** up **directly)** //

pure / stable / anhydrous (not hydrated) / no water loss (no efflorescence) / not deliquescent (not hygroscopic) / does not sublime / high formula (molecular, molar) mass (M_r)

ANY TWO: (3 + 2)

(b) DESCR: **rinse (wash)** from clock glass **into beaker** and **dissolve** //
pour (add) using funnel (glass rod) into 500 cm^3 **volumetric flask** and **add rinsings** of beaker //
add deionised* water until bottom of meniscus on (level with) mark / read at eye level //
stopper and **invert** (not "shake") **several times** ANY FOUR: (4 × 3)
**[Accept if "deionised water" appears elsewhere in candidate's description.]*

CALC: **2.65** g (6)

$$\frac{\mathbf{500 \times 0.05 \times 106^*}}{\mathbf{1000}} \quad (3) \quad = \quad \mathbf{2.65} \quad (3)$$

** Addition must be shown for error to be treated as a slip.*

(c) *(i)* **fill above mark and adjust with tap / fill to below mark and add dropwise** (3)

(ii) **safety / avoid solution getting into mouth / hygiene** (3)

(d) NAME: **indicator** (3)

CHANGE: **colour before // colour after** (2 × 3)

Indicator	Colour before	Colour after
Methyl orange	Orange (yellow)	Red (pink)
Methyl red	Yellow	Red (pink)
Methyl yellow	Yellow	Red (pink)
Bromophenol blue	Blue (purple, violet)	Yellow
Bromocresol green	Blue	Yellow

[Linked marks - suitable indicator is a requirement for award of marks for matched colours]

(e) CALC: *(i)* **0.12** M (9)

$$\frac{\mathbf{20.8} \times \mathbf{M_{HCl}}}{\mathbf{2}} = \frac{\mathbf{25 \times 0.05}}{\mathbf{1}} \quad (6)$$

M_{HCl} = **0.12** (3)

(ii) **4.38 / 4.39** g l^{-1} (3)

$0.12 \times 36.5^*$ = **4.38** (3)

** Addition must be shown for error to be treated as a slip.*

NOTE: Treat answers not given to two decimal places as slips.

QUESTION 2

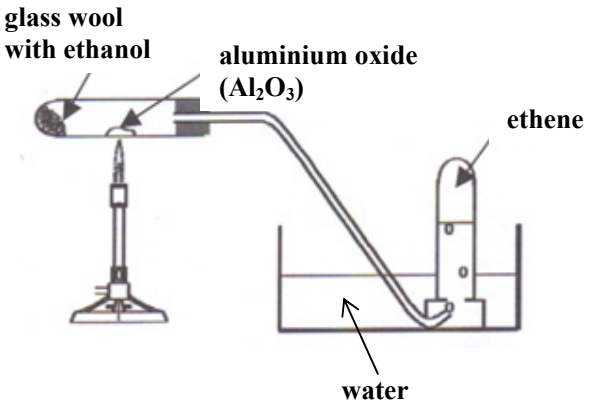
(a) DRAW: **ethanol on glass wool (or other suitable material) positioned correctly** (3)

aluminium oxide (3)

heated (3)

collection arrangement / collection over water / using trough (2)

No diagram: – 3



(b) *(i)* **when heat is removed (stopped, interrupted) / at the end** (3)

(ii) cold **water** sucked **in**to **test tube / test tube cracks / fire / explosion / injury** due to broken glass (3)

(iii) **remove delivery tube** from water before removing heat / **loosen stopper** before removing heat (3)

(c) TEST: **reagent used** (3)

bubble through (shake with) // colour before // colour after ANY TWO: (2 × 3)

Reagent used	**Colours**
Bromine (Br_2) water (soln) (3)	**Red (orange, yellow, brown)** (3) **to colourless***[not "clear"]* (3) *[Allow 3 marks for decolourise]*
Acidified manganate(VII)* solution (3)	**Purple (violet, pink)** (3) **to colourless** *[not "clear"]* (3) *[Allow 3 marks for decolourise]*

******For "manganate(VII)" accept "permanganate," "$KMnO_4$," and "MnO_4^-."*

(d) WRITE: $\mathbf{C_2H_5OH \longrightarrow C_2H_4 + H_2O}$ (6)

[Accept with Al_2O_3 over arrow or written on <u>both</u> sides of equation.]
[Allow for 3 marks $C_2H_5OH \longrightarrow C_2H_4$]

(e) NUMBER: **8** test tubes (15)

2.4 × 0.8 = **1.92** g ethanol (3)

1.92 ÷ 46* = 0.042 (0.0417) mol ethanol = **0.042 (0.0417)** mol ethene (3)

0.042 (0.0417) × 24000 = **1008 (1002)** cm^3 (3)

60% of 1008 (1002) = **605 (601)** cm^3 (3)

60% of 0.042 (0,0417) = **0.0252 (0.025)** (3)

0.0252 (0.025) × 24000 = **605 (600)** cm^3 (3)

605 (601 / 600) ÷ 75 = **8** test tubes of ethene (3)

***** *Addition must be shown for error to be treated as a slip.*

Note: Use of 22.4 litres as molar volume loses 3.

QUESTION 3

(a) GIVE: **propanone (acetone)** (56 °C) / **propanal** (49 °C) / **methanol** (65 °C) / **trichloro-methane {chloroform}** (61 °C) / **hexane** (69 °C) / **other suitable liquid** (5)
[Accept **ethanol** (78 °C), **ethyl ethanoate** (77 °C), **cyclohexane** (81 °C).*]*
[Accept formula].

(b) (i) Apparatus **A***

weigh flask + fittings // heat **until** all **liquid gone (until vaporised) , cool, dry and reweigh //** mass is **difference (find difference)**

or

Apparatus **B***

weigh small syringe + contents // **inject liquid and reweigh //** mass is **difference (find difference)** (3 × 3)

(ii) Apparatus **A***

fill flask with water **and empty into measuring (graduated) cylinder**

or

Apparatus **B***

read volume **from** scale of **gas syringe /** find **diff. between** initial and final **readings** (6)

(c) EXPL: **the pinhole (in apparatus A*) means //**
vapour exposed to (in contact with) the **air (atmosphere) / vessel is open to atmosphere**
or
the **plunger** (in apparatus **B***) **is free to move (moves) //**
until vapour pressure reaches atmospheric pressure (until pressure is equal inside and outside) / plunger **stops when pressure equalises** (2 × 3)
*N.B. Marks to be awarded for either **A** or **B** and not for a mixture; if the candidate gives answers for both methods, mark them separately and award the marks for the better of the two.*

(d) MOL: **0.01076** [*Allow* **0.01** to **0.011** mol] (9)

equation of state (correct) (3)		$\frac{\mathbf{V_{room}}}{\mathbf{293^*}} = \frac{\mathbf{330}}{\mathbf{373}}$ (3)	
$\frac{\mathbf{101 \times 10^3 \times 330 \times 10^{-6}}}{\mathbf{8.3 \times 373}}$ (3)	*or*	V_{room} = **259** cm^3 (3)	
= **0.01076 to 0.011** (3)		259 ÷ 24000 = **0.0108** (3)	

**similar method at s.t.p.*

M_r : **57** to **63** (6)

0.63 ÷ 0.01076 to 0.011 (3)
= **57 to 63** (3)

(e) WHY: **do not vaporise easily / boiling points too high / boiling points too near (higher than) boiling point of water / boiling points too near (higher than) 100 °C (373 K) / have to vaporise below 100 °C** (3)

WHAT: **mass spectrometer** (6)

SECTION B

Question 4

Eight items to be answered. Six marks to be allocated to each item and one additional mark to be added to each of the first two items for which the highest marks are awarded.

(a) STATE: *(i)* **5**, *(ii)* **9** (2 × 3)

(b) WRITE: $^{131}_{53}\mathbf{I} \longrightarrow {}^{131}_{54}\mathbf{Xe} + {}^{0}_{-1}\mathbf{e}\ ({}^{0}_{-1}\boldsymbol{\beta})$ (6)

[Marks may be awarded if all numbers are inverted]

(c) DEFINE: **average mass of atom(s)** of element / **average of isotopes taking abundances into account //**

relative to (based on) $^1/_{12}$ the mass of a **carbon-12** atom (2 × 3)

(d) DISTING: *sigma*: **head-on (end-on) overlap of orbitals //**

pi: **lateral (sideways) overlap of p-orbitals** (2 × 3)

[Marks can be got from clear diagrams. Allow only 3 if "orbitals" omitted from statements or not labelled in diagrams.]

(e) BALANCE: $\mathbf{Cu + 2NO_3^- + 4H^+ \longrightarrow Cu^{2+} + 2NO_2 + 2H_2O}$ (6)

(f) STATE: **equal (same) volumes of gases contain equal (same) numbers of molecules {moles, particles, atoms** (for noble gases)**}** //

under same (*not "all"*) **conditions (temp. and pressure)** (*not "at s.t.p."*) (2 × 3)

[Allow (3) for 'molar volume at s.t.p. = 22.4 litres']

(g) WHY: **more collisions (particles, molecules, reactants) reach activation energy / more collisions are effective** (6)

[Allow 3 marks for 'increase in number (or energy) of collisions']

(h) NAME: *(i)* **hydrogen** // *(ii)* **hydroxyl (hydroxide, OH^-)** ions (2 × 3)

(i) DEFINE: average energy required **to break a bond (to break 1 mole of bonds) and to separate the atoms {into separate (single) atoms** or **in the gaseous state}** (6)

(j) WHAT: **biological (biochemical, by micro-organisms, by bacteria, by activated sludge) //**

oxidation (decomposition, digestion, breakdown) of sewage (2 × 3)

(k) **A**: *Low*: have **branching** causing space(s) between chains //

High: very **little (no) branching,** chains closer (little space between chains) (2 × 3)

[Allow shorter chains for low and longer chains for high]

or

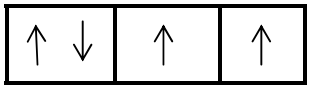
B *Scrub*: **lime (CaO) / limestone ($CaCO_3$) //**

reacts with (removes) waste acidic **gases** (2 × 3)

[Can be shown by equation]

QUESTION 5

(a) WRITE: $1s^2 2s^2$ // $2px^2 2py^1 2pz^1$ /

$1s^2 2s^2$ // $2p^4$ **and** 

(3 + 2)

[Accept with subscripts, also $2p_x^2{}_y^1{}_z^1$. The electron pair can be in any one of the p orbitals. Lines or dots will do in place of arrows in the boxes.]

(b) DEFINE: **half internuclear distance (half distance between the centres** of the atoms**) in a single homonuclear bond (of singly-bonded atoms of the** same **element)** (6)

STATE: **decrease** in atomic radius (3)

EXPLAIN: **increase in** effective **nuclear charge (number of protons)** (3)

(c) REASON: **increase in nuclear charge (number of protons) / decrease in atomic radius** (3)

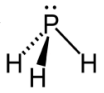
(d) *(i)* STATE: **PH_3** virtually **non-polar** (pure **covalent**) but the **other three** are **polar** covalent (3)

WHAT: **tiny (no) electronegativity difference in PH_3 (between P and H)** but much **big**ger **electronegativity differences in the other three.** (3)

(ii) FROM: **H_2O** // **NH_3** (2 × 3)
[Award 6 marks if H_2O, NH_3 and HCl offered]

GIVE: **melting point / boiling point / surface tension / capillarity / specific heat / latent heat of fusion / latent heat of vaporisation / density / solubility in water** (3)

(iii) SHAPE: **pyramidal** (3)

EXPL: repulsion between **four electron pairs (e.p.), one a lone pair (l.p.) /** 

repulsion between **three bonds (bond pairs, b.p.) and a (one) lone pair (l.p.)** (3)

(e) WOULD: *(i)* B – Cl bond: **polar** // *(ii)* BCl_3 molecule: **non-polar** (2 × 3)

JUSTIFY: **unequal sharing of electrons (el. neg. difference)** between B and Cl **(polarity of bonds) cancels due to symmetry of molecule(s) /**
centres of positive and negative charge coincide (3)

QUESTION 6

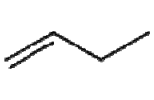
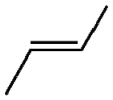
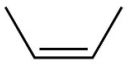
(a) NAME: *(i)* **dehydrocyclisation (cyclodehydrogenation) / reforming //**

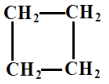
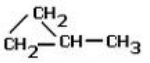
(ii) catalytic **cracking //**

(iii) **isomerisation / reforming** (3 + 3 + 2)

(b) HYDROCARBON: **but-1-ene (1-butene) / but-2-ene (2-butene) / 2-methylpropene** (3)

STRUCTURE: $\mathbf{CH_2{=}CHCH_2CH_3}$ / $\mathbf{CH_3CH{=}CHCH_3}$ / $\mathbf{CH_3C(CH_3){=}CH_2}$ **[$(CH_3)_2C{=}CH_2$]**

 /  or  /  (3)

Accept **cyclobutane (**  /  **) & methylcyclopropane (**  /  **)**

[Name and formula must match. If the formula is fully expanded the H atoms may be omitted.]

PRODUCT: **2,2,4-trimethylpentane / *iso*octane** (3)

OCTANE NUMBER: **100** (3)

(c) EXPLAIN: **increase octane number / prevent auto-ignition (pre-ignition, early ignition, ignition before spark, knocking, pinking)** (3)

NAME: **lead** compounds e.g. tetraethyl lead *[Allow benzene]* (3)

STATE: **toxic (poisonous, health hazard** to living things**) /**
poisons (damages) catalytic converters /
pollutes the environment (3)

NAME & STATE are unlinked.

(d) DEFINE: energy released (heat change) when **1 mole** of a substance //
is burned (reacts) completely in oxygen / is burned (reacts) in excess oxygen (2 × 3)

NAME: **bomb calorimeter** (3)

(e) CALCULATE: **– 224** kJ mol^{-1} (12)

$8CO_2 + 9H_2O \rightarrow C_8H_{18} + 12½O_2$	ΔH = **5502** kJ	(3)
$8C + 8O_2 \rightarrow 8CO_2$	ΔH = **– 3152** kJ	(3)
$9H_2 + 4½O_2 \rightarrow 9H_2O$	ΔH = **– 2574** kJ	(3)
$8C + 9H_2 \rightarrow C_8H_{18}$	ΔH = **– 224** kJ	(3)

Equations not required

$\Delta H_{(combustion)}$ =	$\Sigma\Delta H_{f(products)} - \Sigma\Delta H_{f(reactants)}$	
=	$\Sigma\Delta H_{f(products)} - \{-$ **3152** (3) – **2574** (3)$\}$ = **5502**	(3)
or =	$\Sigma\Delta H_{f(products)}$ + **3152** (3) + **2574** (3) = **5502**	(3)
or =	**5502** (3) – **3152** (3) – **2574** (3) = – **224** kJ	(3)

[+224 merits 3 marks only]

QUESTION 7

(a) CAUSE: dissolution of **calcium ions / calcium hydrogencarbonate / calcium sulfate / calcium chloride / other soluble calcium salt /magnesium ions / magnesium hydrogencarbonate / magnesium sulfate / magnesium chloride / other soluble magnesium salt** *[Accept formulas]* (3)

WASTE: soap used up in **react with** Ca and Mg **ions** to give scum (3)
[Could be shown by an equation e.g. $2RCOO^- + Ca^{2+} \rightarrow (RCOO)_2Ca$]

DE-ION: pass through resin to **replace positive ions (named + ion) with hydrogen ions (H^+) //** and **negative ions (named – ion) with hydroxyl (hydroxide) ions (OH^-)** (3 + 2)

(b) PURPOSE:
(i) **clumping (coagulating, joining together) of** fine **particles (solids) //**
(ii) **kills pathogens** {harmful **bacteria (micro-organisms)}** / **sterilises //**
(iii) **prevents tooth decay / strengthens enamel //**
(iv) **raises pH //**
(v) **lowers pH** (5 × 3)

STATE:
(i) slight **danger to health / acidification / corrosion /** affects **taste / tooth decay** //
(ii) **toxic (poisonous) / odour** of chlorine / **taste** of chlorine //
(iii) **toxic (poisonous) / stains (mottles) teeth //**
(iv) **pH too high (too basic) / causes hardness /** affects **taste //**
(v) **pH too low (too acidic) / corrosion / tooth decay** ANY TWO: (2 × 3)

(c) CONCERN: **danger to health (toxic, poisonous) /** may cause **foetal abnormalities / minamata disease** (3)

NAME: **atomic absorption spectroscopy (atomic absorption spectrometry)** (6)
[Allow 3 marks for AAS]

EXPLAIN: **precipitation / coagulation / complexation / adsorption / absorption / reverse osmosis / ion exchange / deionising** (3)

(d) TEST: **add silver nitrate ($AgNO_3$)** and dilute nitric acid //
white precipitate (ppt) formed (2 × 3)
[white ppt linked to correct reagent]

QUESTION 8

(a) GIVE: *(i)* **propan-2-ol / 2-propanol** (5)

[Allow 3 marks for 'propanol']

(ii) **propyl methanoate** (3)

(b) EXPLAIN: compounds with the **same molecular formula //**

but having **different structures (different structural formulas) / arranged differently in space** (2 × 3)

WHAT: *primary*: **RCH_2OH / contains CH_2OH / one carbon attached to OH carbon /** at least **two Hs attached to OH carbon / OH on end carbon //**

secondary: R**CHOH**R^1 **/ contains CHOH / two carbons attached to OH carbon / only one hydrogen attached to OH carbon** (2 × 3)

IDENTIFY: **propanal** and **propanone** (6)

(c) CPD: **A / alcohol A / propan-2-ol / propan-1-ol** (3)

[Allow 'propanol']

(d) NAME: *reagent*: **hydrogen //**

catalyst: **nickel / palladium / platinum** (2 × 3)

[Accept lithium aluminium hydride and sodium borohydride for 3 only. Accept formulas.]

(e) DESC: **mix (add)** equal amounts of **Fehling's A (1) and Fehling's B (2)** in a test tube //

add a small amount of **propanal //**

heat / warm / place in water bath (may be got from a diagram) //

note any **change / red precipitate (ppt)** formed / **copper(I) oxide (Cu_2O)** formed / **blue colour changes**

ANY THREE: (3 × 3)

WHY: propanone **not easily oxidised / not oxidised by Fehling's reagent / poor reducing agent /** **Fehling's reagent a** very **weak oxidising agent** (too **weak an oxidising agent)** (3)

(f) WHICH: **B / ester / ester B / propyl methanoate / $HCOOC_3H_7$** (3)

[Accept the ester given as answer in (a) (ii) even if incorrect.]

QUESTION 9

(a) DEFINE: **change in concentration per unit time / rate of change of concentration /**

$$\frac{\textbf{change in concentration}}{\textbf{time}}$$ (5)

PLOT: See graph below.

axes correctly labelled *[Accept "time" or "s"; "mass" or "g"]* //
axes correctly scaled //
points correctly plotted *[Assume (0,0) correctly plotted]* //
curve accurately drawn from origin (4 × 3)
[Note: if graph paper is not used, accuracy must be checked with a ruler.]

USE: **2.0×10^{-3}** to **3×10^{-3}** g/s (6)
[Allow 3 marks for tangent]

MARK: See graph below.

curve drawn with the following:
rises to half the height //
less steep at the start / levels off later (2 × 3)

JUSTIFY: less steep at the start due to **lower concentration** of HCl //
levels of later as reaction slower due to **lower concentration** of HCl //
rises to half the height due to HCl **concentration being halved (amount** of HCl **present is halved)** ANY ONE: (3)
[It must correspond with the relevant feature of the curve.]

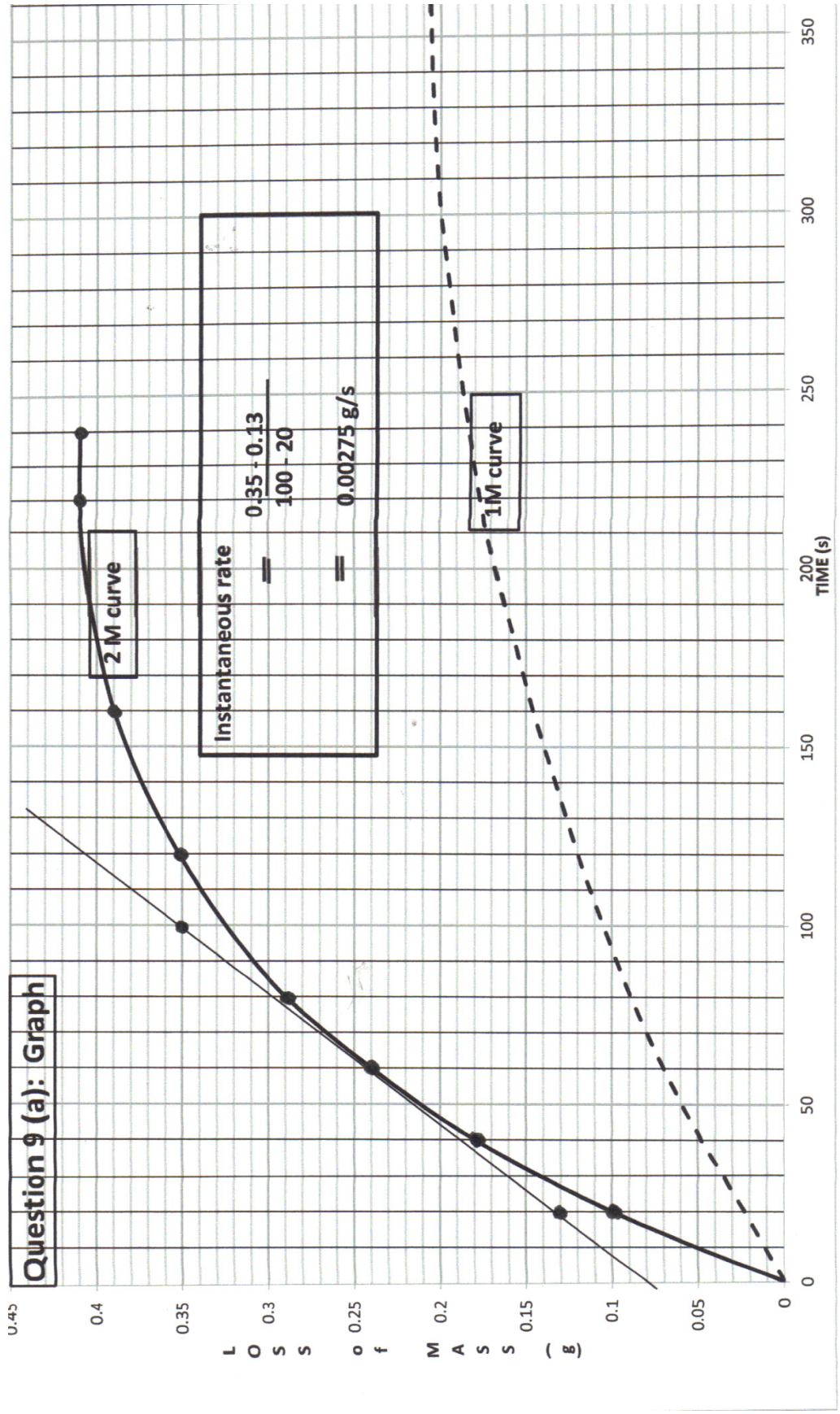
(b) TYPE: **homogeneous** (3)

COLOURS: **pink to green** back **to pink** (6)

EXPLAIN: **pink at start is colour of catalyst (Co^{2+})** solution //

green due to formation of **intermediate (complex)** //

pink at end as catalyst (Co^{2+}) restored (released, reformed) (3 × 3)
[Clearly link colour to catalyst // colour to intermediate // and colour to restoration of catalyst for (3 × 3)]


Question 9 (a): Graph
2 M curve
1M curve
Instantaneous rate
0.35 - 0.13
100 - 20
0.00275 g/s
Loss of Mass (g)
TIME (s)
0
50
100
150
200
250
300
350
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4

QUESTION 10

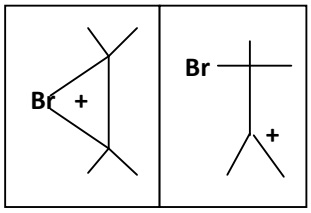
(a) *(i)* presence of **double bond (unsaturation) //**

which is **electron rich /** which can **donate electrons** / which is a **nucleophile /**
pi bond weak (pi bond more **easily broken) / high electron density** (4 + 3)

(ii) MECHANISM:

polarisation of Br_2 / $Br^{\delta+}$– $Br^{\delta-}$ under influence of double bond //

followed by **heterolytic fission / splitting into ions / Br^+&(+) Br^- //**



addition of bromonium ion (Br^+) across (to) the double bond /
addition of Br^+ forming bridged intermediate (cyclic bromonium ion)
*[Obtainable from correct diagram. Accept localised **carbonium ion**.*
Also accept cyclic bromonium ion with poitive charge on the Br] //

attack (addition) of bromide ion (Br^-) to bridged intermediate /
attack (addition) of bromide ion (Br^-) to cyclic Br^+ /
attack (addition) of bromide ion (Br^-) to carbonium ion (C^+) (4 × 3)
[The information in this point may also be got from a suitable diagram (equation).]

STATE: **when named nucleophiles (anions, negative ions) present (alternative nucleophile source {e.g. Cl^- or NaCl (HCl); OH^- or H_2O}) and an identified matched product** (6)
[May be got from example e.g. 2-bromoethanol if (bromine) water is present. Structural formulas accepted.]

(b) DEFINE: **proton (hydrogen ion, H^+) donor**

WHAT: acid and base that **differ by a proton (hydrogen ion, H^+)** (4 + 3)

STATE: **purple //**

EXPLAIN: **hydroxyl (hydroxide) ions (OH^-) remove hydrogen ions (H^+) causing the reaction (equilibrium) to shift forward (to the right)** (2 × 3)

CALC: *(i)* pH =**13.7** (6)

pOH = – log 0.5 = **0.3** (3)
pH = 14 – 0.3 = **13.7** (3)

$[H^+]$ = 10^{-14} ÷ 0.5 = **2×10^{-14}** (3)
pH = – log 2×10^{-14} = **13.7** (3)

(ii) pH =**2.85** (6)

pH = **$-\log\sqrt{2.0 \times 10^{-5} \times 0.1}$** (3)
= **2.85** (3)

$[H^+]$ = $\sqrt{2.0 \times 10^{-5} \times 0.1}$ (3)
pH = - log $[H^+]$ = **2.85** (3)

(c) *(i)* WHAT: **aluminium / Al** (4)

(ii) HOW: **0.0003** mol sulfur (6)

0.0096 ÷ **32** (3) = **0.0003** (3)

(iii) MASS: **0.0054** g aluminium (9)

0.0003 mol S ≡ **0.0003** mol Ag_2S (3) ≡ **0.0002** mol Al (3) = **0.0054** g Al (3)

(iv) LOSS: **0.0744** g lost (6)

0.0003 mol S ≡ **0.0003** mol Ag_2S (3) × 248* = **0.0744** (3)

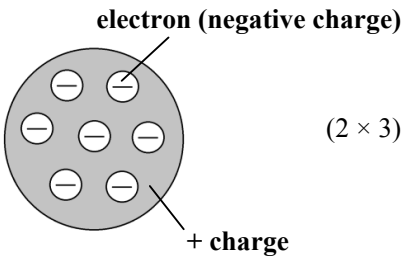
** Addition must be shown for error to be treated as a slip.*

QUESTION 11

(a) *(i)* WHAT: **helium nuclei (-eus) / He^{2+} /** particle having **two protons and two neutrons** (4)

(ii) DESC: **sphere (ball) with positive (+) charge** spread out over it //

with **electrons embedded (scattered, dotted, placed** at random) **in it** (2 × 3)



*[Marks can be got from a labelled diagram. The words "electron(s)/ negative charges" and "positive (+)" required in description or diagram. Dots(**e**s) may be used for electrons.]*

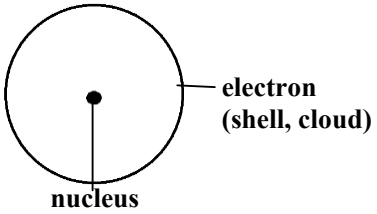
(iii) EXPL: **repelled //**

when passing **near (by) nucleus {near (by) positive (+) core (centre)}** (2 × 3)
[The two 3s could be got from a suitable diagram.]

(iv) SOME: **collided with nucleus {positive (+) core (centre)} //**

SMALL: **nucleus {positive (+) core (centre)} very small /**
most (almost all) of atom's **mass** concentrated **in nucleus {positive (+) core (centre)} /**
most (almost all) of atom is empty space (2 × 3)

(v) DRAW: **nucleus {central mass (core) shown and labelled with one (or more) shell(s) of electrons (or electron cloud) shown and labelled** (3)



(b) WRITE: $\dfrac{[I_3^-]}{[I_2][I^-]}$ (6)

CALC: **704.95 / 705** M^{-1} (12)

I_2	+	I^-	$\rightleftharpoons$	I_3^-
Start 0.0800 M		0.2400 M		0.0000 M
Equil **0.0007** M (3)		**0.1607** M (3)		0.0793 M

$\dfrac{\mathbf{0.0793}}{\mathbf{0.0007 \times 0.1607}}$ (3) = **704.95 / 705** (3)

STATE: concentration of triiodide ions **decreases**

EXPLAIN: reaction **shifts backward (reverse, to the left) to restore (increase) iodine** conc. (4 + 3)
[Linked responses]

Question 11 continued/

(c) **A** *(i)* **heating (digestion)** of the bauxite **with sodium hydroxide (NaOH) //**

to produce soluble **sodium aluminate ($NaAlO_2$) //**

seeding with crystals of **aluminium oxide trihydrate ($Al_2O_3.3H_2O$) //**

precipitation of aluminium oxide trihydrate ($Al_2O_3.3H_2O$) /
conversion of sodium aluminate ($NaAlO_2$) to aluminium oxide trihydrate ($Al_2O_3.3H_2O$) //

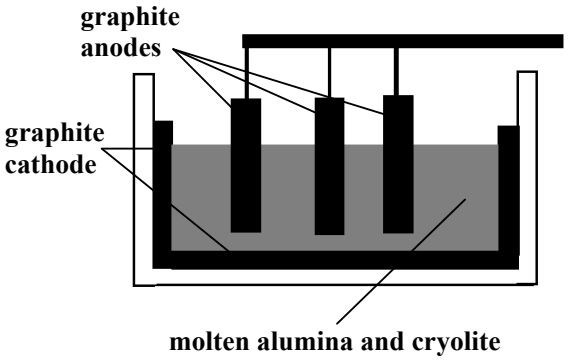
heating to remove water from $Al_2O_3.3H_2O$ ANY FOUR: (4 × 3)

(ii) **graphite anode(s) labelled //**

graphite cathode labelled //

molten alumina and cryolite labelled

[No diagram: – 3]



(3 × 3)

(iii) **saves energy / cheaper / avoids litter / prevents loss of aluminium / conserves natural resources** (4)

B *(i)* in **flushing (purging)** oil **tanks /** as **inert atmosphere /** in **preserving food /** in **keeping food fresh /** in **packaging food (crisps) / over gas (oil, flammables) in tankers (being transported) /** in **glass production /** in **semiconductor (micro-chip) production /** to **dilute atmospheric oxygen / production of ammonia (urea, nitric acid, fertilisers)** (4)

(ii) **high energy (strong, difficult to break) bond //**

non-polar //

triple bond ANY TWO: (2 × 3)

(iii) **conversion of** atmospheric **nitrogen //**

to useful (chemically **reactive) compounds** (2 × 3)

(iv) lightning supplies the **high temp {extreme heat (energy)}** required for N_2 to combust //

nitrogen combines with oxygen to produce nitrogen(II) oxide (NO, nitric oxide, nitrogen monoxide) / $N_2 + O_2 \rightarrow 2NO$ //

NO combines with oxygen to give nitrogen(IV) oxide (NO_2, nitrogen dioxide) /
$NO + \frac{1}{2}O_2 \rightarrow NO_2$ / $\frac{1}{2}N_2 + O_2 \rightarrow NO_2$ / $N_2 + 2O_2 \rightarrow 2NO_2$ //

NO_2 combines with moisture (H_2O) to give nitrite (nitrate) /
$2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$ ANY THREE: (3 × 3)

[Equations need not be balanced.]