Coimisiún na Scrúduithe Stáit
State Examinations Commission

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Ceimic *Ardleibhéal*

Marking Scheme *Leaving Certificate Examination, 2005*

Chemistry *Higher level*

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Leaving Certificate Examinations 2005

Chemistry – Higher Level

Marking Scheme

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.

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

Section A [At least <u>two</u> questions must be answered from this section]

1. (a) Why 5 or 3; (b) Why conc. 6; (c) Describe 2 x 3, 3; (d) Describe 3 x 3; (e) Indicator 3, When 3, Colours 3; (f) Calculate 6; (g) Calculate (6).

2. (a) Why 5; (b) Two features 4 x 3; (c) Describe 2 x 3, Account 3; (d) Test 2 x 3, Observe 2 x 3; (e) Mass 12.

3. (a) Equation 5; (b) Draw 4 x 3; (c) Which 3, Reason 3; (d) Graph 3, 6, 3; (e) Use (i) 3, (ii) 6; (f) What 2 x 3.

Section B

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

4. (a) 2 x 3; (b) 2 x 3; (c) 6; (d) 2 x 3; (e) 2 x 3; (f) 2 x 3; (g) 2 x 3; (h) 6; (i) 2 x 3; (j) 2 x 3; (k) A 2 x 3, (k) B 6.

5. (a) Isotopes 5, Name 3, Example 6, Use 3; (b) Define 2 x 3, Describe (i) across 3, Account 2 x 3 or 6, Describe (ii) down 3, Account 3; (c) Define 2 x 3, Distinguish 2 x 3.

6. (a) (i) Name 2 x 4, (ii) State 2 x 3, (iii) Why 3, (iv) Identify 3; (b) 3 x (2 x 3), (c) 12.

7. (a) Name 5; (b) Classify 4 x 3; (c) Describe 4 x 3, How 2 x 3; (c) State 2 x 6 + 3.

8. (a) Define (i) 4, (ii) 4; (b) Identify 2 x 3; (c) Calculate 12; (d) BOD 2 x 3; (e) Describe: *primary* 2 x 3, *secondary* 2 x 3, What 2 x 3.

9. (a) State 2, 3; (b) (i) Describe 4 x 3, (ii) Describe 3 x 3; (c) (i) Write 6, (ii) Calc. 18.

10. (a) (i) Calc. 8 ; (ii) Calc. 5; (iii) Calc. 6; (iv) Calc. 6.
(b) (i) Identify 4, State 3; (ii) Equation 6; (iii) Would 3, Explain 3; (iv) How 3, React 3.
(c) State 4 + 2 x 3, Describe 5 x 3.

11. (a) (i) Define 4; (ii) What 3, Explain 2 x 3; (iii) Electrode 3, Which 3, Write 2 x 3.
(b) (i) Define 7; (ii) State 2 x 3; (iii) How many 12.
(c) A (i) What 4 x 3; (ii) Name 3; (iii) Describe 9; (iv) Give 2 x 3.
(c) B (i) Account 4 + 3; (ii) What 3, State 2 x 3; (iii) Describe 3 x 3.

SECTION A

At least *two* questions must be answered from this section.

QUESTION 1

(a) WHY: **so that oxygen content doesn't increase (change) due to photosynthesis / so that oxygen content doesn't decrease (change) due to respiration / so that oxygen content doesn't change (increase/decrease) due to activity of organisms in the water** (5)
[*the oxygen content may change over time* / *due to respiration of micro-organisms / due to photosynthesis of plant material* Any one of these merits only (3)]
[Allow 3 marks for *"accuracy"*. Also allow only (3) for "*decrease due to photosynthesis"* or "*increase due to respiration"* as a contradiction is present.]
Note: do not award marks for attempts like "*may absorb oxygen from the air*" or "*may become contaminated from the air (atmosphere)*" – the bottle is stoppered.

(b) WHY CONC.: **to minimise the amount of the water sample that is displaced** / **minimise the change in the oxygen dissolved in the sample / so that a small volume (amount) supplies excess** (6)
[Allow 3 marks for *"to prevent water being displaced"*/ *"accuracy"*/ *"excess reagents"* / *"solutions to sink to bottom"* / *"oxygen content of solutions added may be different"*]

(c) DESCRIBE: **remove a few cm^3** of river **water from the bottle /** addition made **so that water overflows from the bottle //**
make additions **under the level of the water** //
using a dropper (pipette, syringe) //
do not bubble air (oxygen) into the water in the process // ANY TWO: (2 × 3)

WHAT: **do not trap air (oxygen)** bubbles (3)

(d) DESCRIBE: **rinse with water followed by iodine //**
fill pipette using a pipette filler to above the mark (graduation line) //
adjust to have bottom of meniscus on mark / **read at eye level (vertically)** //
remove droplets adhering to outside //
drain under gravity **into titration flask** //
touch tip of pipette against side of flask to add droplet adhering to outside tip //
do not blow out drop inside pipette ANY THREE: (3 × 3)

(e) INDICATOR: **starch** (3)
WHEN: **when the solution is straw-yellow (light yellow, straw-coloured) / becomes pale** (3)
COLOURS: **blue-black (black, blue, indigo, navy) to colourless** (do not accept *"clear"*) (3)

(f) CALCULATE: **0.0006 / 6 x 10^{-4}** mol l^{-1} (6)

$$\frac{50 \times X}{1} = \frac{6.0 \times 0.01}{2} \quad (3)$$

$$X = 0.0006 / 6 \times 10^{-4} \quad (3)$$

(g) CALCULATE: **9.6** p.p.m. (6)

$0.0006 \div 2 = 0.0003$ (3)
$0.0003 \times 32 \times 1000 = 9.6$ (3)

QUESTION 2

(a) WHY: **volatile product / ethanal has low b.p. / ethanal boils at about 21 °C (room temp)** (5)

(b) TWO FEATURES: **first feature** (3) **explanation** (3); **second feature** (3) **explanation** (3)

excess ethanol/dichromate limiting	(3)	stops at ethanal/doesn't go to ethanoic acid / prevents further (over) oxidation	(3)
immediate distillation (removal)	(3)	ethanal removed before oxidation / prevents further (over) oxidation	(3)
dichromate in funnel	(3)	small amount of oxidising agent in flask	(3)

(c) DESCRIBE: **orange** solution added to colourless liquid // **becomes green** (2 × 3)
ACCOUNT: **Cr(VI) / $Cr_2O_7^{2-}$** is reduced to **Cr(III) / Cr^{3+}** (3)

(d) TEST: **mix (add)** equal amounts of **Fehling's 1 (Fehling's A / copper sulfate/$CuSO_4$ solution)** and **Fehling's 2 (Fehling's B, alkaline/sodium hydroxide/NaOH solution with Rochelle salt/potassium sodium tartrate/potassium sodium 2,3-dihydroxybutanedioate)** (3)

add ethanal and **warm / heat / put** test tube **in hot (boiling) water** (3)

OBSERVE: brick-**red** (accept orange/brown) (3)
precipitate produced (3)

(e) MASS: **2.97** g [Accept 2.948 – 3.000 g] (12)

8.94 g sodium dichromate $\xrightarrow{\div 298^*}$ 0.03 mol (3)

0.03 mol dichromate ≡ 0.09 mol ethanal (3)

0.09 mol ethanal $\xrightarrow{\times 44^*}$ 3.96 g ethanal (3)

75 % yield = $\frac{3.96 \times 75}{100}$ = 2.97 g (3)

OR

75 % yield = $\frac{0.09 \times 75}{100}$ = 0.0675 / 0.067 / 0.068 mol (3)

0.0675 mol $\xrightarrow{\times 44^*}$ 2.97 g (3)

[**addition must be shown for error to be treated as slip*]

QUESTION 3

(a) EQUATION: **$2H_2O_2 \rightarrow O_2 + 2H_2O$ / $H_2O_2 \rightarrow \frac{1}{2}O_2 + H_2O$** (5)
[Allow 3 marks if all formulas are correct]

(b) DRAW: **reaction vessel with hydrogen peroxide and catalyst** (3)

method of ensuring correct start time (stated or shown) e.g. catalyst in neck of horizontal flask; bring flask to vertical and start clock / catalyst in small test tube in flask; mix and start clock / add catalyst, stopper, and start clock (3)
[N.B. Descriptions of starting reaction and clock at same time must be clear. Adding peroxide from funnel is not acceptable as start time is not exact and volume collected is incorrect due to displacement of air.]

delivery tube connected to gas collection system (syringe or over water) (3)

clear method of measuring (e.g. syringe with calibrations or inverted graduated cylinder) (3)
[At least one label required]

(c) WHICH: **finely / former / first option** (3)
REASON: **greater activity** / **greater surface area** available (3)

(d) GRAPH: **labelled and scaled axes** [Accept "*time*" or "*minutes*"; "*volume*" or "cm^3".] (3)
points plotted correctly (6)
[Allow 3 marks if six or more points plotted correctly; assume (0, 0) is plotted correctly]
curve drawn [has to be drawn to (0, 0)] (3)

Note: the (6) for points plotted correctly not given if graph paper not used.

(e) USE:

(i): **26.5 – 28.5** cm^3 (3)

(ii): **6.0 – 8.0** $cm^3\ min^{-1}$ [Accept in $cm^3\ s^{-1}$] (6)
[For answers outside this range, (3) may be given for a good tangent drawn at the correct point on the graph]

(f) WHAT: **rise less steep / levels off later** (3)
maximum volume 20 cm^3 / half the final volume / less oxygen produced (3)
Note: changes may be shown on the candidate's graph paper or through a suitable sketch.

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) **relative (measure of) attraction / number expressing (giving) attraction** (3)
for shared electrons / for electrons in a covalent bond (3)

(b) **linear / straight** (both available from diagrams, including shape diagrams using (3)
bent / angular / "v"-shaped correct examples. No marks for "planar". Cancelling does not (3)
apply for "planar" but does for descriptors like "triangular".)

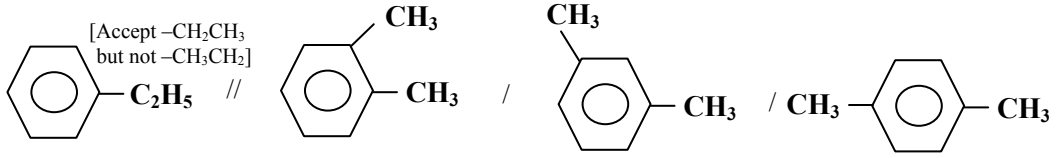
(c) **Balmer** (Accept phonetically similar efforts starting with B like "*Bahlmer*", "*Bahmer*", "*Bamer*" but not efforts like "*Balman*", "*Balmyn*" or "*Palmer*".) (6)

(d) he grouped **elements of similar properties** (3)
in groups of three / triads / description of triad (3)

(e) atomic orbitals are three dimensional **spaces** about the nucleus of an atom **where there is a high probability of finding an electron / region in which electron is likely to be found** (3)
an atomic sub-level is a sub-division of a main energy level **consisting of** one or more **orbitals of the same energy / discrete energy values available in** main **level (shell)** (3)

(f) **add** concentrated solution of **iron(II) sulfate ($FeSO_4$) followed by** concentrated **sulphuric acid (H_2SO_4) down the side of the test tube.** (3)
a brown ring develops at the junction of the two solutions (3)

(g) **ethylbenzene** // **dimethyl benzene** (numbers not needed) / **xylene** (3)

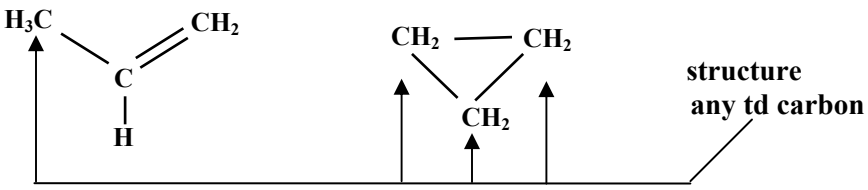


[Three correctly-placed double bonds in ring acceptable] (3)

(h) **$CuCl_2$** (6)

Cu = 3.175 ÷ 63.5 = 0.05; Cl = (6.725 – 3.175) ÷ 35.5 = 0.1 (3)
Ratio Cu : Cl = 0.05 : 0.1 = 1 : 2 (3)

(i)



(3)
(3)

[Allow **$CH_3CH{=}CH_2$** (3) **C of CH_3 tetrahedral** (3)]

(j) **$C_2H_5OH + Na \longrightarrow C_2H_5ONa + ½H_2$ / $2C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2$** FORM: (3) BAL: (3)
[Allow 3 marks for correct formula for the organic product]

(k) A: **$Cl^\bullet + O_3 \longrightarrow ClO^\bullet + O_2$** (3) // **$ClO^\bullet + O^\bullet \longrightarrow O_2 + Cl^\bullet$ / $ClO^\bullet + O_3 \longrightarrow Cl^\bullet + 2O_2$** (3)

B: **oxidised (corroded, loses electrons, forms pos. ions) more easily** than protected metal / **higher in electrochemical series** than protected metal / **forms cell** in which **protected metal is** the **cathode** [Allow 3 marks for *"more reactive"*] (6)

QUESTION 5

(a) ISOTOPES: atoms of **same element (same atomic number, same Z, same number of protons)** with **different mass numbers (different A, different number of neutrons)** (5)

NAME: **Becquerel** (3)

GIVE: **Example** (mass number essential) (6) **Use** (3)

Deuterium, H-2; (nuclear fusion); carbon-13 (tracers in biosynthesis); carbon-14 (dating of ancient remains); caesium-135 (measurement of second); cobalt-60 (radiotherapy, cancer treatment, sterilisation); americium-241 (smoke alarms); phosphorus-32 (plant nutrient tracer, medical e.g. bone scans, radiotherapy); iodine-125 (medical tracer); caesium-137 (radiotherapy); oxygen-18 (reaction mechanisms); technetium-99 (medical tracer); uranium-235/uranium-238 (weapons, power); etc.,
[Must be matched. Note: mass number essential]

(b) DEFINE: **half internuclear distance / half the distance between the centres** (3)
in a single homonuclear bond / of singly-bonded atoms of the same element (3)

DESCRIBE (i) ACROSS: **decrease** in atomic radius (3)

ACCOUNT: **increase in nuclear charge** (3)
constant screening effect **(of inner shells) / same no. of** (inner) **shells** (3)
or **increase in effective nuclear charge** for 6 marks
[The marks for ACCOUNT cannot be awarded if the answer to ACROSS is incorrect.]

DESCRIBE (ii) DOWN: **increase** in atomic radius (3)

ACCOUNT: **increase in number of** filled **shells** (3)
[The marks for ACCOUNT cannot be awarded if the answer to DOWN is incorrect.]

(c) DEFINE: involving the **sharing** (3)
of one or more pair(s) of **electrons** (3)

DISTINGUISH: sigma – **"end-on" ("head-on") overlap of orbitals / no nodal line** (3)
pi – **"side-on" ("sideways", "lateral") overlap of p-orbitals** or *d*- or *f*- orbitals (3)
[Both can be got from diagrams. However, if the marks are to be awarded on the basis of diagrams, orbitals must be clearly labelled so that, for the π bond, overlapping "figures of 8" must be labelled as p orbitals, or else p orbitals must be specified in the accompanying text, and, similarly, the word "orbitals" must be used in connection with the σ bond, either as a label on the diagram, or in the accompanying text.]

QUESTION 6

(a) (i) NAME: **2,2,4-trimethylpentane (*iso*octane)** // **heptane (*n*-heptane)** (2 x 4)

(ii) STATE: **short** chain length / **branching** / **ring (cyclic) / aromatic** ANY TWO: (2 x 3)

(iii) WHY: **catalyst poison** / **destroys catalytic converter** (3)

(iv) IDENTIFY: **oxygenate / alcohol / methanol / ethanol / ether (alkoxyalkane) / methyl-*t*-butyl ether (MTBE, 2-methoxy-2-methylpropane)** (3)

(b) **$CH_3CH_2CH_2CH_2CH_3$ / $CH_3(CH_2)_3CH_3$** (3) **pentane** (3)

$(CH_3)_2CHCH_2CH_3$ / $CH_3CH_2CH(CH_3)_2$ (3) 2-**methylbutane** (3)

$(CH_3)_4C$ / $(CH_3)_3CCH_3$ / $(CH_3)_2C(CH_3)_2$ (3) 2,2-**dimethylpropane** (3)

[Matching of names and formulae <u>are</u> required. In expanded structures, bonds without Hs are acceptable. Numbers are not required for the methyl branches but, if incorrect numbers are offered (e.g. 1,2-dimethylpropane), then no marks should be awarded.]

(c) **– 3271** kJ mol^{-1} (12)

$C + O_2 \longrightarrow CO_2$ $\Delta H = -394$ kJ mol^{-1} ; $H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$ $\Delta H = -286$ kJ mol^{-1}

$6C + 3H_2 \longrightarrow C_6H_6$ $\Delta H = 49$ kJ mol^{-1}

$2C_6H_6 \longrightarrow 12C + 6H_2$	**– 98** kJ	(3)
$12C + 12O_2 \longrightarrow 12CO_2$	**– 4728** kJ	(3)
$6H_2 + 3O_2 \longrightarrow 6H_2O$	**– 1716** kJ	(3)
$2C_6H_6 + 15O_2 \longrightarrow 12CO_2 + 6H_2O$	– 6542 kJ	
$C_6H_6 + 7\frac{1}{2}O_2 \longrightarrow 6CO_2 + 3H_2O$	**– 3271** kJ	(3)

Equations not required

$C_6H_6 \longrightarrow 6C + 3H_2$	**– 49** kJ	(3)
$6C + 6\,O_2 \longrightarrow 6CO_2$	**– 2364** kJ	(3)
$3H_2 + 1\frac{1}{2}O_2 \longrightarrow 3H_2O$	**– 858** kJ	(3)
$C_6H_6 + 7\frac{1}{2}O_2 \longrightarrow 6CO_2 + 3H_2O$	**– 3271** kJ	(3)

Equations not required

$\Delta H = \Sigma \Delta H_{f(products)} - \Sigma \Delta H_{f(reactants)}$

ΔH = **12 x –394/– 4728** (3) + **6 x –286/–1716** (3) – **{2 x 49/98** (3) + 0}
OR **12 x –394/– 4728** (3) + **6 x –286/–1716** (3) **– 2 x 49/–98** (3) – 0
= – 6542 => ΔH_c = **– 3271** (3)

OR

ΔH = **6 x –394/– 2364** (3) + **3 x –286/– 858** (3) – **{49** (3) + 0}
OR **6 x –394/– 2364** (3) + **3 x –286/–858** (3) **– 49** (3) – 0
=> ΔH_c = **– 3271** (3)

[Allow 3 marks only for + 3271 kJ mol^{-1}]

QUESTION 7

(a) NAME: **chloroethane / ethyl chloride** [Accept with number e.g. 1-chloroethane] (5)

(b) CLASSIFY:
W – elimination
X – addition
Y – addition
Z – substitution (4 × 3)

Note: If the letters W, X, Y and Z are not used, the marks may be allocated based on the order of the conversions in the question e.g. the answer *substitution, addition, elimination, substitution* is worth 6 marks.

(c) DESCRIBE: **horizontal test tube with delivery tube connected collection of gas over water** //

Bunsen burner for heating / **indication of heating** //

aluminium oxide / **Al_2O_3** / **alumina** //

ethanol held at end of test tube (4 × 3)
[minimum of one label required – no labels deduct 3 marks]

Alternatives: (1) flask with delivery tube to collection over water (3) 160 ^oC (3)
sulfuric acid (3) in mixture (solution) with ethanol (3)

(2) flask with delivery tube to collection over water (3) 200 ^oC (3)
phosphoric acid (3) in mixture (solution) with ethanol (3)

HOW: shake with **bromine (Br_2)** water solution /
shake with **acidified (H^+, H_2SO_4)** potassium **manganate**(VII) **(permanganate, $KMnO_4$, MnO_4^-)** (3)
goes colourless (decolorised) (N.B. not 'goes clear') (3)

(c) STATE: reaction requires **u.v. light** of energy high enough to homolyse chlorine **to initiate (start)** //
[Allow 6 or 3 for $Cl_2 \xrightarrow{u\,v} 2\,Cl^{\bullet}$ only if it is described as the "initiation (starting) step"]
for every photon absorbed very many (thousands of) molecules of a product are formed //
[Statements such as "each photon produces very many (thousands of) radicals" merits no marks as each photon actually only produces two radicals.]
if irradiation (u.v.) is stopped the reaction slows down (stops) / **reaction doesn't proceed in the dark** /

products such as butane / chlorobutane / etc. formed (i.e. alkanes and haloalkanes with a multiple of 2 carbons from C_4 upwards can only be explained by a radical mechanism) //

addition of **radical promoters (radical sources, scavengers, tetramethyl lead, tetra-ethyl lead) alter (speed up) the rate of the reaction** ANY THREE: (2 × 6 + 3)

QUESTION 8

(a) DEFINE: (i) *acid*: **proton (hydrogen ion, H^+) donor** (4)
(ii) *base*: **proton (hydrogen ion, H^+) acceptor** (4)

(b) IDENTIFY: **acid** (3) **its conjugate base** (3)

acid = H_2F^+ (3)	its conjugate base = HF (3)
acid = HCl (3)	its conjugate base = Cl^- (3)

[If not specified as acid and conjugate base, take the order in the question to be the intended order. Accept if indicated correctly on the equation.]

(c) CALCULATE: **3.22** / **3.22** (12)

$pH = -\log\sqrt{K_a \times M}$ (3)

$pH = -\log\sqrt{1.8 \times 10^{-4} \times 0.002}$ / $-\log\sqrt{3.6 \times 10^{-7}}$ / $-\log 0.0006$ / $-\log 6 \times 10^{-4}$ (3)

$pH = 3.22$ (6)

OR

$[H^+]^2 = K_a.M$ / $1.8 \times 10^{-4} \times 0.002$ / 3.6×10^{-7} (3)*

$[H^+] = \sqrt{1.8 \times 10^{-4} \times 0.002}$ / $\sqrt{3.6 \times 10^{-7}}$ / 0.0006 / 6×10^{-4} (3)*

$pH = 3.22$ (6)

*$[H^+]^2$ and $[H^+]$ are required in the case of these marks.

(d) BOD: p.p.m. (mg l^{-1}) (amount) of **oxygen consumed** (3)
when sample **kept in the dark for five days at 20 ^oC (293 K)** (3)

(e) DESCRIBE: *primary*: **removal of solids (large particles*, floating debris, large items, twigs, etc.)** (3)
by **screening and settlement (sedimentation, grit channels) / physical** (3)
(accept 'large dirt')
secondary: **oxidation / breakdown / use of air (oxygen, *accept both "aerobic digestion" and "anaerobic digestion"*)** (3)
by micro-organisms (bacteria) / biological / chemical / activated sludge (3)

WHAT: **nitrates (nitrogen compounds)** (3)
phosphates (phosphorus compounds) (3)

QUESTION 9

(a) STATE: reactions **at equilibrium** (2) **oppose** (*Accept 'minimise', 'relieve'*) **applied stress(es)*** (3)
**If the word stress(es) is replaced by particular examples (e.g. pressure), <u>all three</u> (temp., pressure & conc.) must be given.*

(b) (i) DESCRIBE: **choice of methods**

Method 1
make solution of (dissolve, put) potassium dichromate (3)
in water (3)

$$\mathbf{Cr_2O_7^{2-} + H_2O \rightleftharpoons 2CrO_4^{2-} + 2H^+}$$

FORMULAS: (3) BALANCING: (3)

Method 2A
make soln of cobalt chloride
in hydrochloric acid

Method 2B
make soln of cobalt chloride
in water

Method 2C
make soln of cobalt chloride (3)
in water and add HCl to inter-
mediate colour (violet, lilac) (3)

$$\mathbf{CoCl_4^{2-} + 6H_2O \rightleftharpoons Co(H_2O)_6^{2+} + 4Cl^-}$$

FORMULAS: (3) BALANCING: (3)

[Accept
make solution of hydrochloric acid (3)
in water (3)

$$\mathbf{HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-}$$] (6)

<u>Note</u>: the equations may be given in reverse.

(ii) DESCRIBE: **choice of methods**

Method 1
add sodium hydroxide
the solution changes from **orange**
to yellow

Method 1 (alternative)
Add HCl (no marks)
solution changes from **yellow** (3)
to orange (3)

Method 2A
add water
solution from **blue**
to pink (purple)
(Accept 'red' in place of 'pink' for Method 2)

Method 2B
add HCl
solution from **pink**
to blue

Method 2C(a)
add water
soln from **intermed.**
to pink (purple)

Method 2C(b)
add HCl (3)
soln from **intermed.** (3)
to blue (3)

[Accept
add sodium hydroxide (3)
monitor pH using a pH meter or pH probe (3)
note increase in pH] (3)

(c) (i) WRITE: $\dfrac{[CH_3COOC_2H_5][H_2O]}{[CH_3COOH][C_2H_5OH]}$ (6)

(ii) CALC: **14.08 – 14.96** g (18)

$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$

0.25 mol* 0.25 mol* 0 mol 0 mol (3)

[* *addition must be shown for error to be treated as slip*]

$0.25 - x$ $0.25 - x$ x x (3)

$\dfrac{x^2}{(0.25-x)^2} = 4$ (3)

$\dfrac{x}{0.25-x} = 2 \;/\; 3x^2 - 2x + 0.25 = 0$ (3)

$x = {}^1/_6 \;/\; 0.16^{\bullet}$ [allow 0.16 / 0.17] (3)

${}^1/_6 / 0.16^{\bullet} \times 88 = 14.6^{\bullet}$ (14.08 – 14.96) (3)

OR

$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$

0.25 mol* 0.25 mol* 0 mol 0 mol (3)

[* *addition must be shown for error to be treated as slip*]

x x $0.25 - x$ $0.25 - x$ (3)

$\dfrac{(0.25-x)^2}{x^2} = 4$ (3)

$\dfrac{0.25-x}{x} = 2 \;/\; 3x^2 + 0.5x - 0.0625 = 0$ (3)

$0.25 - x = {}^1/_6 \;/\; 0.16^{\bullet}$ [allow 0.16 / 0.17] (3)

${}^1/_6 / 0.16^{\bullet} \times 88 = 14.6^{\bullet}$ (14.08 – 14.96) (3)

QUESTION 10 : Answer any *two* of the parts (a), (b) and (c).

(a) (i) CALC: **20 / 21** cm^3 [(–1) for answer not given to nearest cm^3 or given in litres] (8)

2 x 0.3 = 0.6 g $\xrightarrow{\div 58^*}$ 0.01 / 0.0103 mol	(3)
0.01 / 0.0103 mol $Mg(OH)_2$ ≡ 0.02 / 0.021 mol HCl	(3)
volume of 1.0*M* HCl = 20 / 21 cm^3	(2)
[* *addition must be shown for error to be treated as slip*]	

(ii) CALC: **0.95 – 0.99** g [*correct to second decimal place*] (5)

0.01 / 0.0103 mol $Mg(OH)_2$ ≡ 0.01 / 0.0103 mol $MgCl_2$	(3)
0.01 / 0.0103 mol $MgCl_2$ $\xrightarrow{x\ 95^*}$ 0.95 – 0.98 g	(2)
[* *addition must be shown for error to be treated as slip*]	

(iii) CALC: **$6 \times 10^{21} - 6.21 \times 10^{21}$** (6)

0.01 / 0.0103 mol $MgCl_2$ ≡ 0.01 / 0.0103 mol Mg^{2+}	(3)
0.01 / 0.0103 x 6×10^{23} = $6 \times 10^{21} - 6.21 \times 10^{21}$	(3)

(iv) HOW: **10 cm^3** (6)

6 % (w/v) = 6 g in 100 cm3	(3)
=> 0.6 g in 10 cm3	(3)

(b) (i) IDENTIFY: **first ionisation energy / first ionisation potential** (4)
[Allow 3 marks for ionisation energy (potential)]

STATE: **kilojoules per mole (kJ mol^{-1}) / joules per mole (J mol^{-1}) / electron volt(s) (eV)** (3)

(ii) EQUATION: $\mathbf{X_{(g)} \longrightarrow X^+_{(g)} + e^-}$ / $\mathbf{X_{(g)} - e^- \longrightarrow X^+_{(g)}}$ (6)
[Allow (3) for equation given without state symbols]

(iii) WOULD: **less** (3)

EXPLAIN: **already gained energy (partially removed) / already raised to higher level /** already **excited /further from nucleus** (3)
[The (3) for EXPLAIN cannot be awarded if the answer to WOULD is incorrect]

(iv) HOW: **very / quite / fairly / reactive** (3)

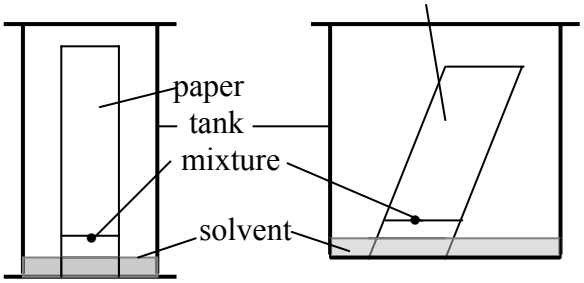
REACT: by **losing electron(s) / oxidised / becoming positively charged** (3)

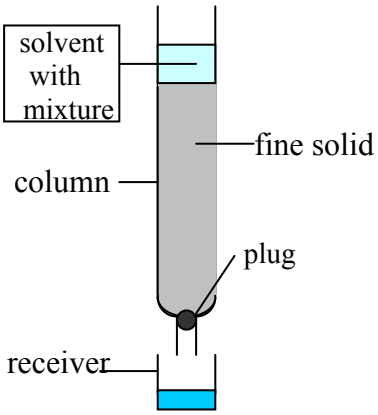
Question 10 continued/

(c) STATE: separation of a mixture of components

based on their selective **adsorbance on / based on their** relative **affinities (attractions) for** / **based on their partitioning between** / **based on their** different **interactions with //**
a stationary phase //
and a mobile phase / while carried by a mobile phase (4 + 2 × 3)
[There can be no suggestion that the components react chemically with either the mobile or stationary phases]

DESCRIBE: Three methods:





Paper Chromatography	Thin-layer chromatography	Column chromatography
Apply mixture using dropper (capillary tube) / spotting on paper //	Apply mixture using dropper (capillary tube) / spotting on plate //	Dissolve mixture in solvent (eluent*) / apply mixture to top of column //
About 2 cm above bottom of sheet / just above eluent (or from top – see below) //	About 2 cm above bottom of plate / just above eluent //	Add to top of column / add solvent to top of column //
Place in eluent* (solvent, mobile phase) in tank (sample above solvent) //	Place in eluent* (solvent, mobile phase) in tank (sample above solvent) //	Continue to add eluent (solvent, mobile phase) so that it flows down through column //
Elute (solvent moves up – or down – see below) //	Elute (solvent moves up) //	Separation occurs / bands shown //
State or show separation of components of mixture	State or show separation of components of mixture.	Collect different components / show separation into bands
*Accept named eluent	*Accept named eluent	*Accept named eluent
All (5 × 3) written or through a labelled diagram or diagrams (See N.B. below.)		

Note 1: The elution stage (point 4 above) must be clearly cited, either by a statement to that effect, or by clearly shown (labelled) solvent fronts in the case of paper or thin-layer chromatography.

Note 2: in paper chromatography, the solvent may be at the top of the tank with the mobile phase moving down.

N.B. no diagram – or diagram not having at least one label – : deduct 3, if at least 3 marks have been awarded.

QUESTION 11: Answer any <u>two</u> of the parts (a), (b) and (c).

(a) (i) DEFINE: **increase** in oxidation number (4)

(ii) WHAT: solution turns **red-brown (red, orange, yellow)** (3)

EXPLAIN: **bromide** ions oxidised **to bromine / Br^- ⟶ Br_2 / Br(-1) to Br(0)** (3)

chlorine reduced **to chloride** ions / **Cl_2 ⟶ Cl^- / Cl(0) to Cl(-1)** (3)
[NaBr & NaCl can replace Br^- & Cl^- respectively]

[All 6 marks can be got for a single complete equation representing what happens]

(iii) ELECTRODE: **A / anode / positive electrode** (3)

WHICH: **H_2O (water)** (3)

WRITE: **$H_2O \longrightarrow ½O_2 + 2H^+ + 2e^-$ / $2H_2O \longrightarrow O_2 + 4H^+ + 4e^-$ /**
$3H_2O \longrightarrow ½O_2 + 2H_3O^+ + 2e^-$ / $6H_2O \longrightarrow O_2 + 4H_3O^+ + 4e^-$ /
$H_2O - 2e^- \longrightarrow ½O_2 + 2H^+$ / $2H_2O - 4e^- \longrightarrow O_2 + 4H^+$ /
$3H_2O - 2e^- \longrightarrow ½O_2 + 2H_3O^+$ / $6H_2O - 4e^- \longrightarrow O_2 + 4H_3O^+$
FORMULAS: (3) BALANCING: (3)
[Allow 3 marks for a balanced equation representing the oxidation of hydroxide ion]

(b) (i) DEFINE: has **as many (**same **number of) particles* as 12 g (0.012 kg) of carbon-12 /**
contains the **Avogadro number (Avogadro constant, *L*, 6 x 10^{23})** of **particles* /**
the relative **formula mass (molecular mass) in grams (g)** (7)
[Accept "*atoms*", "*ions*" or "*molecules*" in place of "*particles*"]

(ii) STATE: **equal (same) volumes of gases contain equal (same) numbers of molecules (particles, moles)** (3)
under same conditions of temperature and pressure *(Do not accept "at s.t.p.")* (3)
[Allow 3 marks for *"one mole of a gas at s.t.p. occupies 22.4 litres"*]

(iii) HOW MANY: **2.4 x 10^{22} – 2.5 x 10^{22}** atoms (12)

10 % (v/v) = 10 cm^3 per 100 cm^3 / 10 litres per 100 litres	(3)
=> volume of helium = 1 litre	(3)
= $^1/_{24}$ mol / 0.0416• mol	(3)
x 6 x 10^{23} = 2.4 x 10^{22} – 2.5 x 10^{22} atoms	(3)

Question 11 continued/

(c) Answer either part **A** or part **B**

A

(i) WHAT: **monomers (small molecules) combining (linking, joining) to form a polymer (large molecule, giant molecule, big molecule)** (4 + 3)

(ii) NAME: **Plunkett** (3)

(iii) DESCRIBE: **$nCF_2CF_2 \rightarrow (-CF_2CF_2-)_n$** // **$nCF_2CF_2 \rightarrow (-CF_2-)_{2n}$** (9)

[Allow 3 marks for the correct formula for **CF_2CF_2**;
3 marks for 2 or more repeating units; and 3 marks for a multiple i.e. "n"]
[If expanded structure of CF_2CF_2 is given then the double bond must be shown; no end dashes in **$(—CF_2CF_2—)_n$ or $(—CF_2—)_{2n}$** - lose 3 marks; incorrect "n" – lose 3 marks] [Accept **C_2F_4** for **CF_2CF_2**]

(iv) GIVE: **medical body parts (qualified) e.g. blood vessels, joints, corneas, tracheas) // dental work (qualified) // stain resistance on fabrics and wood (qualified) (e.g. carpets, curtains, clothes, floors) // non-stick surfaces // plumbing tape // paints // windscreen wipers // lubricants // burette taps** ANY TWO: (2 × 3)

B

(i) ACCOUNT: **high bond energy (strong / difficult to break) // non-polar // triple bond** ANY TWO: (4 + 3)

(ii) WHAT: **conversion of atmospheric nitrogen to** nitrogen **compounds that can be used (useful compounds, chemically reactive)** (3)

STATE: **electrical storms (lightning) // legumes (Rhizobium) (named legume) // alder (Plasmodiophorales) // nitrogen fixing bacteria (Azotobacter, Clostridium, Krebsiella) // blue-green algae (Cyanophyceae, Anabaena) // photosynthetic bacteria** (2 × 3)

(iii) DESCRIBE: **spark plug (electrical discharge) / high temperature / compression (high pressure)** in the ignition system **provides the energy for (allow facilitates)** the first reaction (3)

$N_2 + O_2 \rightarrow 2NO$ / **$\frac{1}{2}N_2 + \frac{1}{2}O_2 \rightarrow NO$** (3)

$NO + \frac{1}{2}O_2 \rightarrow NO_2$ / **$2NO + O_2 \rightarrow 2NO_2$** (3)

[Allow 6 marks for the combined equation
$N_2 + 2O_2 \rightarrow 2NO_2$ or **$\frac{1}{2}N_2 + O_2 \rightarrow NO_2$**
but no marks unless fully correct and balanced]