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Leaving Certificate Examination 2002

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.
Words, expressions or statements separated by a solidus (/) are alternatives which are equally acceptable. A word or phrase in bold, given in brackets, is an acceptable alternative to the preceding word or phrase.

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) Compound 4, Process 4; (b) Describe 4 x 3; (c) Name 3, Washing & Filling 3 x 3, Indicator 3; (d) Conc. dil. vinegar 6, Original vinegar 3, Percentage 6.

2. (a) Chem. diff. 5; (b) What else 6, Why reflux 6 or 2 x 3, Ethanol 3; (c) Why remove 6, 3; (d) Minimum 6, Brine 3; (e) Describe 6, Precaution 6.

3. (a) Identify 5; (b) Preparing 4 x 3; (c) Plot 4 x 3, Conclusion 6; (d) How long 9; (e) Explain 6.

Section B:

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

5. (a) Define 3, 3, 2; (b) Increase 2 x 3, Drops 3 x 3; (c) Down II 2 x 3; (d) Explain 6, 3; (e) $2^{nd} – 3^{rd}$ 6 or 3, Next 3, Reason 3.

6. (a) Which 4, Reason 4; (b) Names 3, 3, 3, 3, 3; (c) Class 3, 3, 3; (d) Reagents 6, 2 x 3; (e) Give 6.

7. (a) Mass spec. 4, Gas chr. 4; (b) Principles 3 x 3, 3 x 3; (c) Process 5 x 3; (d) HPLC 2 x 3, Application 3.

8. (a) LPG 5, Isomers 3, 3; (b) Why 3, What 3, Source 3; (c) Feature 3, Other 3; (d) Define 2 x 3, Calculate 18.

9. (a) Property 5, (i) 3 x (2 x 3), (ii) Stage 3, Name 3, State 3; (b) (i) Primary 2 x 3, Secondary 2 x 3, (ii) Tertiary 2 x 3.

10. Answer any **two** of the parts (a), (b) and (c).
(a) Define 4, (i) Oxidised 6 or 2 x 3, Reduced 6 or 2 x 3, (ii) Balance 9.
(b) (i) Colour 4, (ii) Explain 4 x 3, (iii) Evidence 2 x 3 or 6, (iv) Why 3.
(c) State 3, 4, (i) Expression 6, (ii) Calculation 12.

11. Answer any **two** of the parts (a), (b) and (c).
(a) (i) 4, (ii) 6, (iii) 9, (iv) 6.
(b) What 4 +3 or 7, Describe 4 x 3, Explain 2 x 3.
(c) **A**: Batch 3, Continuous 3, (i) 4, (ii) 5 x 3.
B: (i) 4, (ii) 5 x 3, (iii) 2 x 3.

Section A

At least <u>two</u> questions must be answered from this section

QUESTION 1

(a) COMPOUND: **ethanol / ethyl alcohol / C_2H_5OH** (4)

PROCESS: **oxidation** (4) *can be got from reaction scheme but only if oxidation is shown by symbol or otherwise.*

(b) DESCRIBE: **pipette (burette)** vinegar (3) *can be shown on diagram*

into **volumetric flask** (3) *can be shown with diagram provided line on neck present*

add deionised **water** (3)

when near mark, add **dropwise (using dropper/pipette/wash bottle)** / **until bottom of meniscus on (at) mark / read bottom of meniscus** (3)

(c) NAME: **burette** (3)

WASHING & FILLING: with **deionised water / then solution (ethanoic acid, diluted vinegar)** / use of **funnel** (**pour in at top**) / **ensure that the area below (jet, tip, nozzle) the tap is filled** *(not 'the tap is filled')* (3 x 3)

<u>Note</u>: if pipette is named the marks for rinsing with deionised water, then solution, can be given.

INDICATOR: **phenolphthalein / thymolphthalein / thymol blue / cresol purple / neutral red / phenol red / bromothymol blue** (3)

Cancelling applies to INDICATOR

(d) CONC DIL VIN: **0.15** (6) [20.5 x M = 25 x 0.12 (3) M = 0.15 (3)]

ORIG VIN: **1.5** (3) [0.15 x 10 (3)] [Accept 0.075 moles per 50 cm^3 or 90 g / l for 3 marks]

<u>Note</u>: if a value has not been worked out for the concentration of the original vinegar, (3) consequential marks can be given for the percentage calculation but only if a number (e.g. the answer to conc dil vin) is multiplied by 60 and the product obtained is divided by 10 – the (3) is given for the result of the division by 10; marks for the fully correct answer can of course be given.

PERCENTAGE: **9** (6) [1.5 x 60 = 90 g l^{-1} (3) 90 ÷ 10 = 9 % (3)]

<u>Note</u>: answers can be given to more decimal places.

QUESTION 2

(a) CHEM DIFF: **animal saturated (all single bonds) / vegetable unsaturated (double bonds) /**

have **different degree (level) of saturation (unsaturation) / animal more saturated (less unsaturated, fewer double bonds) / vegetable more unsaturated (less saturated, more double bonds) / vegetable polyunsaturated / vegetable can be hydrogenated** (5)

Cancelling applies here but only in cases where there is a clear, direct contradiction in the candidate's answer.

(b) WHAT ELSE: **anti-bumping** agent / suitable **named anti-bumping material** (6)

WHY REFLUX: because **reaction is slow / to complete reaction (hydrolysis, saponification)** (6) // **to boil (heat)** (3) **without losing** volatile **material (ethanol)** (3)

ETHANOL: **solvent** for lard (3)

(c) WHY REMOVE: **easier to isolate soap /** some **soap dissolved in ethanol (soap won't precipitate fully) / soap contaminated with ethanol (smells of ethanol, not pure, not got on its own) / more brine needed / avoid waste of ethanol (recover ethanol for further use) /ethanol not needed for end of experiment.** //

yield reduced / maximize yield (6, 3)

(d) MINIMUM: to minimize **soap remaining dissolved (not precipitating out) / maximise soap precipitating out / so as not to dilute the brine** (6)

BRINE: **salt solution (water) / sodium chloride solution** (3)

(e) DESCRIBE: **filter** (6)

PRECAUTION: **wash with brine** / **wash with** ice-**cold water /** thorough **washing** / use of **indicator (named indicator) / test pH** (6)

'Use excess brine' is not an acceptable answer here.

QUESTION 3

(a) IDENTIFY: **sulfur (sulphur) / S / S_8** (5)

(b) PREPARING: use **burette (pipette, graduated cylinder)** (3) *For list of instruments with one wrong (0)*

to measure **80 (measure 100, remove 20) cm^3** of 0.1 M soln (3)

make up with deionised (distilled) water* (3)

to 100 cm^3** (3)

[ACCEPT: **add 20** cm^3** (3) **deionised (distilled) water*** (3)]

[**NB** *Multiples of 80, 20 and 100 are acceptable e.g. 160 + 40 = 200. In fact, any numbers in 4 : 1 ratio (e. g. 100 + 25) are acceptable (provided 100* cm^3 *or more is produced). If the volume of the 0.08 M solution is less than 100* cm^3 *(-3)*]

(c) PLOT: Note: if graph paper is not used, all marks can be awarded except for the (3) for points correctly plotted.

axes correct and correctly labelled (3, 3) *Accept conc or M and rate or* $^1/_t$

Rate can be on horizontal or vertical axis; similarly for concentration. Axes do not have to begin at zero but the values must be in ascending order.

points correctly plotted (3) [*not given if graph paper not used*]

correct straight line shown passing through origin (3)

CONCLUSION: elationship **proportional (direct proportion) /** $^{\text{rate}}/_{\text{conc (M)}}$ **= k / conc (M) x t = k / conc (M)** $\propto$ $^1/_t$ **/ doubling concentration doubles rate (or vice versa)** (6)

[*Accept increased conc gives increased rate for 3 marks*]

(d) HOW LONG: **2.5** (9) [rate from graph = 0.4 (3) $^1/_t$ = 0.4 (3) t = 2.5 (3)]

[*Accept 0.39 to 0.41 (except 0.4) for 3-1 marks*]

(e) EXPLAIN: **rate and time inversely related / rate** $\propto$ $^1/_t$ **/ rate =** $^{\text{change in conc (M)}}/_{\text{time}}$ **/ increase in time gives** corresponding **decrease in rate (or vice versa) / when rate is doubled time is halved (or vice versa)** (6)

Section B

QUESTION 4

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

(a) atoms of **same element (same atomic number, same number of protons)** (3)
having **different mass** numbers **(different numbers of neutrons)** (3)
Note: give (3) for an example provided same element given twice with different, and correct, mass numbers e.g. C-12, C-14.

(b) **$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$ / $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$ / [Ar]$3d^{10} 4s^1$ / [Ar]$4s^1 3d^{10}$** (6)

(c) **region** around the nucleus **in which there is high probability of finding electron / region in which electron likely to be found / wave function of electron got by solution of Schrodinger's equation** (6)

(d) pH = **3.37 / 3.4** (6)

pH = $-\log\sqrt{K_a \times M}$ / $-\log\sqrt{1.8 \times 10^{-5} \times 0.01}$ (3) = **3.37 (3.4)** (3)

or **$[H^+]^2 = 1.8 \times 10^{-5} \times 0.01$ / $[H^+] = \sqrt{1.8 \times 10^{-5} \times 0.01}$** (3) pH = **3.37 (3.4)** (3)

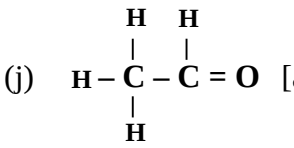
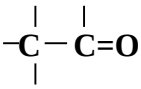
(e) **+ 2 / 2 / 0 and 4** (but only if both are given – no marks for 0 or 4 on its own) (6)

(f) add freshly-prepared, cold, saturated **iron(II) sulfate ($FeSO_4$)** solution, then pour conc **sulfuric acid (H_2SO_4)** carefully down side of slanting test tube (3) /
brown ring at junction of liquids (3) [*Getting (3) for 'brown ring' does not depend on getting first point right.*]

(g) yellow **to orange** (3)
increased H^+ concentration / **shifts forward (to right) / shifts to decrease H^+** concentration (3)

(h) **atomic absorption** spectrometry **/ AAS** (6)

(i) **volume varies directly with Kelvin (absolute) temperature / V/T^* = k / rate of expansion of a gas is $^1/_{273}$ of its volume at 0 °C for each degree Celsius** (3) /
for a definite **mass** of gas at **constant pressure** (3) * must be capital letter.

(j)  [accept ] *must be fully expanded (all bonds shown)* (3) / **ethanal** (3)

(k) **A:** $O_3 \longrightarrow O_2 + O^{\bullet}$ (6)

B: **LDP shorter chains (HDP longer chains) / LDP much branching (HDP little branching) / LDP molecules packed loosely (HDP molecules packed tightly) / LDP flexible (HDP rigid)** ANY TWO: (2 x 3)

QUESTION 5

(a) DEFINE: the minimum energy to **remove most loosely-bound (highest energy, outermost) electron** (3) from an **isolated (gaseous) atom** (3) **in its ground (lowest energy) state** (2)

(b) INCREASE: **increasing nuclear charge (atomic number)** (3) **decreasing atomic radius** (3)

DROPS: **Be <u>or</u> N stable** (3) Be due to **2s full / outer sublevel (subshell)* full /** all **sublevels (subshells)* full /** $1s^2$**2s**^{2} (3)
N due to **half-full** p **sublevel (subshell,)* /** N due to **three half-full p-orbitals /** $1s^2 2s^2$**2p**^{3} (3)
Accept Be <u>or</u> N stable due to full or half-full sublevels (subshells) for the full (9) marks.

OR

B <u>or</u> O unstable (3) B due to **one electron in 2p /** $1s^2 2s^2$**2p**^{1} **/ one electron in outer sublevel (subshell)* / one electron away from stable / loss of electron makes stable** (3)
O due to **pair of electrons in one p-orbital /** $1s^2 2s^2$**2p**^{4} **/ one electron away from stable / loss of electron makes stable** (3)

(c) DOWN II: decrease due to **increasing atomic radius (extra shell or shells) (outer electron further from nucleus)** (3) increased **shielding (screening)** offsets increased nuclear charge **/ effective nuclear charge remains constant** (3)

(d) EXPLAIN: **increasing positive charge** of species losing electron **(no. of protons same but no. of electrons decreasing)** / **decreasing radius** (6, 3)

(e) $2^{nd} - 3^{rd}$: third electron coming from **new shell (new main level) / full shell (full main level) / high stability configuration / noble gas (neon) configuration / stability* of octet / stability* of** $2s^2 2p^6$ **/ stability* of** $ns^2 np^6$ (6)
***** either stated or clearly implied in the candidate's answer. *<u>Note</u>: shell = main level.*
[*Accept electron being removed from a filled p-subshell (filled p-sublevel, p^6) for 3 marks*]

NEXT: between **10th and 11th** (3) *Allow <u>at 11th</u> or <u>from 10th</u>.*

REASON: eleventh electron coming from **new shell (new main level) / full shell (full main level) / high stability configuration / noble gas (helium) configuration /** $1s^2$ (3)
[Note: *If a case is made for 8th and 9th [allow <u>at 9th</u> or <u>from 8th</u>] – allow marks provided fully argued on basis of entering new subshell (subshell) e.g. from 2**p** to 2**s**, (6 or 0)]*

QUESTION 6

(a) WHICH: **A / C_3H_6 / propene** (4)

REASON: **A is non-polar / A cannot form** dipole-dipole (hydrogen) **bonds (intermolecular forces, attractive forces) with water / water is polar / B, C polar / B, C form** hydrogen (dipole-dipole) **bonds (intermolecular forces, attractive forces) with water** (4)

[*Do not accept 'A is not attracted to water', 'A is hydrophobic', 'B,C are attracted to water', 'B,C are hydrophilic*].

(b) NAMES: **A = propene** [*Accept prop-1-ene, 1-propene*] (3) **C = propanone** [*Accept propan-2-one, 2-propanone*] (3)

isomers of **B = propan-1-ol (1-propanol, *n*-propanol, propyl alcohol)** (3)

propan-2-ol (2-propanol, isopropanol, isopropyl alcohol) (3)

isomer of **C = propanal (propionaldehyde)** / **propene oxide** (3)

(c) CLASS: **A: one** (3) **B: three** (3) **C: two** (3)

(d) REAG: A to B: **water** (6) [*Accept 'hydration'.*]

B to C: **sulfuric acid / acidified** (3)
dichromate(VI)**/ chromate**(VI) **/ sodium (potassium) dichromate (chromate) / manganate**(VII) **/ potassium permanganate** (3) //
dehydrogenate by passing over hot **copper** (3) **catalyst** (3)
[*Accept formulas for names of reagents in part (d) ; accept H^+ for acidified*]

(e) GIVE: **removing nail varnish / cleaning glassware / solvent for paints / solvent for lacquers / chromatography / recrystallisation / solvent extraction / solvent for nitrocellulose / dry cleaning / stain (grease) removing** (6)

QUESTION 7

(a) MASS SP: **separating isotopes / measuring relative atomic mass / measuring relative molecular mass / determining structure / identifying** species **/ measuring relative abundance / analysing waste gases** (from cars, dumps, etc.) / **water analysis / drug metabolites / quality control / environmental analysis** (4)

.

GAS CHR: **blood alcohol analysis / drug testing / separating water pollutants / separating alcohols (carboxylic acids, esters, etc.) / working out metabolic pathways / studying enzyme reaction mechanisms / identifying flavourings in drinks / detecting pesticides / organic analysis** for C & H **/ identifying functional groups / hormones in meat / determining position of double bond** in molecule (4)

(b) PRINC: *mass spec*: **charged particle / ionisation** [can be got from (c)] (3)
moving in a magnetic field = acceleration … magnetic field [from (c)] (3)
experiences a force / is deflected in a circular path **according to their mass**/charge ratio (3)
Note: some or all three points can be got from a diagram provided that particles have charges shown or are labelled 'charged particles' or 'ions'. The magnetic field (magnet) must be labelled and a line must be shown deflecting in the magnetic field (this line need not be labelled).

N.B. Award marks for the principles and process of the mass spectrometer on the basis of the candidates answering in both (b) *and* (c). [Even if (b) is not attempted, marks for the mass spec. can be got from (c) and vice versa.]

gas chr: **mobile phase** a gas (3)
stationary phase porous (non-volatile liquid) (3)
separation of the mixture based on different interactions (attractions, adsorptions) with the phases (3)

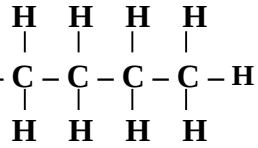
(c) PROCESS: **vaporisation** of sample (3) *correct order of stages not required.*
ionisation to positive ions (3)
acceleration in electric field (3)
separation in magnetic field by mass (3)
detection producing a mass spectrum (3)
[*In this case mark mass spec. elements of (b) and (c) in tandem allowing for transfer of relevant points*]

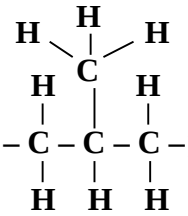
(d) HPLC: **high-performance** [*Accept 'high pressure'*] (3) **liquid chromatography** (3)

APPLIC: **testing for drugs / analysis** of food **for vitamins (impurities), (additives), (growth promoters), (caffeine), (specified food component) / separating dyes / blood alcohol / separating components of something named, etc.** (3)

QUESTION 8

(a) LPG: **liquefied (liquid) petroleum gas** (5)

ISOMERS: **$CH_3CH_2CH_2CH_3$** /  [*Accept sticks without Hs put in*] (3)



$CH_3CH(CH_3)_2$ / [*Accept sticks without Hs put in*](3)

(b) WHY: **to give an odour (smell) / to detect leaks** (3)

WHAT: **greenhouse effect / global warming / trapping heat (IR) / reducing ozone damage / removing chlorine radicals (atoms)** (3)

SOURCE: **fossil fuels / oil / coal (coal gas, coal mines) / marshes (bogs, paddy fields) / animals (cows, sheep, etc.) /dumps (landfill) / slurry / anaerobic decay / compost** (3)

(c) FEATURE: **branching / methyl branches / presence of five (very many) methyl groups (radicals) / short chain** (3)

OTHER: **ring / branching** (unless used above) / **aromatic** / **short chain** (if not used above) (3)

(d) DEFINE: heat when **1 mole** (3) is **burned completely / burned in excess oxygen** (3)

CALCUL: **– 2881** kJ mol^{-1} (18) [– 5762 (15); 2881 (9); 5762 (6)]

$4C + 5H_2 = C_4H_{10}$ $\Delta H = -125$ kJ mol^{-1}

$C + O_2 = CO_2$ $\Delta H = -394$ kJ mol^{-1}

$H_2 + \_O_2 = H_2O$ $\Delta H = -286$ kJ mol^{-1}

$2C_4H_{10} \longrightarrow 8C + 10H_2$ **250** kJ

$8C + 8O_2 \longrightarrow 8CO_2$ **– 3152** kJ

$10H_2 + 5O_2 \longrightarrow 10H_2O$ **– 2860** kJ (6, 3, 3)

$2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$ **– 5762** kJ (3)

$C_4H_{10} + 6\_O_2 \longrightarrow 4CO_2 + 5H_2O$ **– 2881** kJ mol^{-1} (3)

OR

$C_4H_{10} \longrightarrow 4C + 5H_2$ **125** kJ (3)

$4C + 4O_2 \longrightarrow 4CO_2$ **– 1576** kJ (6)

$5H_2 + 2\_O_2 \longrightarrow 5H_2O$ **– 1430** kJ (6)

$C_4H_{10} + 6\_O_2 \longrightarrow 4CO_2 + 5H_2O$ (6) **– 2881** kJ mol^{-1} (3)

OR

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

ΔH = **[4** (3) **(– 394)** (3)+ **5** (3) **(– 286)** (3) – **(– 125)** (3)**]** = **– 2881** kJ mol^{-1} (3) /
[– 1576 (6) **– 1430** (6) **+ 125** (3)**]** = **– 2881** kJ mol^{-1} (3)

Or = **[8**(3)**(– 394)**(3)**+10**(3)**(– 286)**(3) **– 2(– 125)**(3)**]** ÷ **2*** = **– 2881** kJ mol^{-1} (3) /
[– 3152 (6) **– 2860** (6) **+ 250** (3)**]** ÷ **2*** = **– 2881** kJ mol^{-1} (3)

**essential for final (3). Note: because (3)s are available for multiplying by 4 and 5 (or 8 and 10), the products can be given (3) each if minus missing e.g. – 1576 (6), + 1576 / 1576 (3). Thus (9) for +2881, (6) for +5762.*

QUESTION 9

(a) PROPERTY: good **solvent / polar /** readily **forms dipole-dipole (hydrogen) bonds** (5)

(i) *sedimentation*: **settling / sinking down / depositing on bottom** (3)
of **suspended* matter (suspended* solids, suspended* particles, undissolved solids)** (3) * *'suspended' essential here*

flocculation: **adding chemical (flocculating agent, named flocculating agent)** (3)
causing **clumping (coagulating, joining together)** of particles / **helping sedimentation (settlement, filtration)**

filtration: passing **through sand (anthracite, gravel)** (3)
to remove suspended (solids, undissolved) matter (3)

Note: *Solids' and 'undissolved' are alternatives to 'suspended'. For solids, accept particles, grit, dirt, sand, sand, silt, clay.*
Note: simple language acceptable in (i) provided it gives the required information.

(ii) STAGE: **chlorination / sterilisation / fluoridation* / pH adjustment (neutralisation)** (3)

NAME: chlorination: **chlorine / sodium hypochlorite [sodium chlorate(I)]**
OR sterilisation: **chlorine / sodium hypochlorite [sodium chlorate(I)] / ozone**
OR fluoridation: **sodium fluo**ro**silicate (sodium silicofluoride) / ammonium fluo**ro**silicate (ammonium silicofluoride / hexafluorosilicic acid (hydrofluorosilicic acid/**sodium **fluoride/**calcium **fluoride/**tin(II) **fluoride/fluoride**
OR pH adjust: **sodium hydroxide (caustic soda) / calcium hydroxide (lime) / sodium carbonate / soda ash / sulfuric acid / carbon dioxide** (3)
[*Accept formulas in place of names in (ii)*]. [*Fluosilicate ion = SiF_6^{2-}*]

STATE: chlorination: **kills germs (bacteria, micro-organisms) / sterilises / prevents disease**
OR sterilisation: **kills germs (bacteria, micro-organisms) / prevents disease**
OR fluoridation: **prevents tooth decay**
[*Accept 'good for teeth' or 'for healthy teeth' or equivalent*].
OR pH adjust: NaOH, $Ca(OH)_2$, Na_2CO_3, soda ash **raise pH (neutralise acid) /** H_2SO_4, CO_2 **lower pH (neutralise base) /protect pipework** (3)
[**N.B.** stage/name of chemical/state must be matched]

(b) (i) PRIMARY: **removal of solids (large particles, floating debris, large items, twigs, etc.)** (3)
by **screening and settlement (sedimentation, grit channels) /physical** (3)

SECONDARY: **oxidation / breakdown / use of air (oxygen)** (3) [*Accept 'anaerobic digestion'*]
by micro-organisms (bacteria) / biological /chemical* / activated sludge (3)

(ii) TERTIARY: **removal of nitrates (nitrogen compounds)** (3)
and **phosphates (phosphorous compounds)** (3)
[*Accept: to prevent algal bloom, to avoid eutrophication, or to remove plant nutrients for 3 marks*]

QUESTION 10: Answer <u>two</u> of the parts (a), (b) and (c).

(a) DEFINE: **charge on atom if electrons distributed by rules (if bonds assumed ionic)** (4)

(i) **<u>oxidised</u>**: **Cl^- / Cl (–1)** (6) *Cancelling applies.*
[OR **Cl (–1 to 0)** (3) **oxidised** (3)]
<u>reduced</u>: **MnO_4^- / Mn(+7) / Mn(7) / Mn(VII)** (6) *Cancelling applies.*
[OR **Mn (7 to 2)** (3) **reduced** (3)]
<u>Note</u>: candidate may give the required information with the equation and if the candidate attempts to balance the equation here in part (i), balancing marks may be given except for the partial (3) for copying the equation from the exam paper.

(ii) <u>balance</u>: $\mathbf{2}MnO_4^- + \mathbf{10}Cl^- + \mathbf{16}H^+ \longrightarrow \mathbf{2}Mn^{2+} + \mathbf{5}Cl_2 + \mathbf{8}H_2O$ /
$MnO_4^- + \mathbf{5}Cl^- + \mathbf{8}H^+ \longrightarrow Mn^{2+} + \mathbf{2}\_Cl_2 + \mathbf{4}H_2O$ (9)

$\mathbf{2}MnO_4^- \longrightarrow \mathbf{2}Mn^{2+}$ (3)	$\mathbf{10}Cl^- \longrightarrow \mathbf{5}Cl_2$ (3)	$\mathbf{16}H^+ \longrightarrow \mathbf{8}H_2O$ (3)
$MnO_4^- \longrightarrow Mn^{2+}$ (3)	$\mathbf{5}Cl^- \longrightarrow \mathbf{2}\_Cl_2$ (3)	$\mathbf{8}H^+ \longrightarrow \mathbf{4}H_2O$ (3)

<u>Note</u>: partial marks can only be based on one version of the equation. The partial (3) can be given for copying the equation from the exam paper. The marks here are being given <u>for the balancing numbers</u>.

(b) (i) <u>colour</u>: **yellow / orange** (4) [*Accept amber*]

(ii) <u>expl.</u>: **electrons restricted to energy levels (en. values, discrete en.) / en. level diagram** (3)
jump (move, are promoted) to higher levels / fixed energies absorbed (3)
fall back emitting energy as light (electromagnetic energy, photons) (3)
energy difference between levels gives specific (definite) frequency (wavelength, line) of light in spectrum./ **$E_2 - E_1 = h\nu$ (hf)** (3)

OR: **electrons** of atom **in ground state** (3) **absorb photons / become excited** (3)
excited atoms unstable / electrons fall back to lower levels (3)
energy difference between levels gives specific (definite) frequency (wavelength, line) of light in spectrum./ **$E_2 - E_1 = h\nu$ (hf)** (3)
<u>Note</u>: points can be selected from a combination of the two alternatives provided same information not rewarded twice.

(iii) <u>evid.</u>: **only fixed (definite, discrete, specific) frequencies (energies, lines*) are emitted,**(3)
therefore electrons must be restricted to certain (definite, discrete, specific) energy values (levels) (3) * *not 'colours'*
OR: Bohr's **energy levels gave same results as those from spectra** by Balmer and Rydberg (6)

(iv) <u>why</u>: different elements have **different (characteristic, unique, their own) spectra** / **different distribution of energy levels** (3)

(c) STATE: a system **at equilibrium** (3) **reactions oppose applied stresses** (4)

(i) $K_c = \dfrac{\mathbf{[CH_3COOC_2H_5][H_2O]}}{\mathbf{[CH_3COOH][C_2H_5OH]}}$ (6)

(ii) K_c = **4** (12) *Accept **3.7 – 4.3***

0.16$\dot{}$ may be given as 0.16, 0.17, 0.166 etc., 0.3$\dot{}$ as 0.33 etc. Last (3) given even when worked in g

30 ÷ 60 = 0.5 mol; 23 ÷ 46 = 0.5 mol; 10 ÷ 60 = 0.16$\dot{}$ mol

CH_3COOH	+	C_2H_5OH	=	$CH_3COOC_2H_5$	+	H_2O	
0.5 mol		**0.5** mol		0		0	(3)
0.16$\dot{}$ mol		**0.16$\dot{}$** mol	(3)	**0.3$\dot{}$** mol		**0.3$\dot{}$** mol	(3)
OR [**0.3$\dot{}$** mol		**0.3$\dot{}$** mol		**0.16$\dot{}$** mol		**0.16$\dot{}$** mol	(3)]

$\dfrac{\mathbf{0.3\dot{}} \times \mathbf{0.3\dot{}}}{\mathbf{0.16\dot{}} \times \mathbf{0.16\dot{}}} = \mathbf{4}$ (3) **[NB < 3.7/>4.3** (– 1)**]**

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

(a) (i) **bleach / mould (mildew) remover /steriliser / disinfectant** (4)

(ii) **50** (6) 5 % (w/v) = 5g per 100 cm^3 (3) x 10 = 50 g l^{-1} (3)

(iii) **4 x 10^{22}** (9) 5 ÷ 74.5* = 0.067 mol (3) ⇒ 0.067 mol Cl_2 (3) x 6 x 10^{23} = 4 x 10^{22} (3)

*Using formula mass of OCl^- (–3) Rounding off to 0.06 mol (–1)

(iv) **1.5** l / **1500 – 1503** cm^3 (6) 0.067 x 22.4 = 1.5 (6)
Rounding off to 0.06 *not* penalised a second time.
<u>Note</u>: accept answers given to <u>one significant figure</u>.

(b) WHAT: **helium** (4) **nuclei** (3) // $^{4}_{2}He$ / He^{2+} / **two protons and two neutrons** (7)
[*Accept:* ***atomic no. 2, mass no 4 for*** *(7)*]

DESCRIBE: **bombarded gold foil (leaf) with α-particles** (3)

used **zinc sulfide detector /** phosphorescent **screen / detector** for scattered a-particles (3)

most* passed straight through / **some* deflected** at large angles **/ some reflected (bounced back)** (2 x 3)
***** *If the candidate omits <u>most</u>* from *'most passed straight through', the candidate can be given the marks for this point by stating for the second point that <u>a small number</u> are deflected.*

EXPLAIN: The only possible explanations for the observations are:
mass concentrated (contained in small space) / positive charge concentrated (contained in small space) / atom is **mostly empty space** ANY ONE: (6)

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

A BATCH: **feedstock (raw materials, reactants) in vessel gives product / process repeated with new lot** (3)

CONTIN: **feedstock (raw materials, reactants) fed in at one end; product out at other end** (3)

(i) <u>NH_3</u>: **natural gas supply / workforce available / sea for cooling / transport available / local demand for product / important for economy / important for agriculture**

<u>HNO_3</u>: **ammonia rail link / workforce available / transport available / local demand / important for economy / important for agriculture**

<u>MgO</u>: **vacant factory suitable / workforce available / transport available / raw materials near** (4)

(ii) $\underline{NH_3}$: **hydrogen from methane natural gas / nitrogen from air (atmosphere) /**
$CH_4 + H_2O \rightleftharpoons CO + 3H_2$ / nickel catalyst* / $CO + H_2O = CO_2 + H_2$ /
high pressure (40 – 250 atm) / high temperature (300 – 700 ^oC) / iron catalyst*
* *term 'catalyst' required unless clear from the context.* ANY FOUR: (4 x 3)

$N_2 + 3H_2 \rightleftharpoons 2NH_3$ ($\_N_2 + 1\_H_2 \rightleftharpoons NH_3$) (3)

$\underline{HNO_3}$: **equation for ammonia oxidation: $4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$ /**
$2NH_3 + 2\_O_2 \longrightarrow 2NO + 3H_2O$ (3) //

high pressure (2–15 atm) / high temp (750–1100 ^oC) / platinum-rhodium catalyst* /
NO reacts with oxygen to give NO_2 / $NO + \_O_2 \rightarrow NO_2$($2NO + O_2 \rightarrow 2NO_2$) /
thisreacts with water to give HNO_3 / $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$
* *term 'catalyst' required unless clear from the context.* ANY FOUR: (4 x 3)

$\underline{MgO}$: **lime (calcium hydroxide) produced from limestone (calcium carbonate, $CaCO_3$)** /
$CaCO_3 \longrightarrow CaO + CO_2$ / CaO (quicklime) with water gives $Ca(OH)_2$ (lime) /
$CaO + H_2O \longrightarrow Ca(OH)_2$ / reaction with the $MgCl_2$ in **seawater /**
magnesium hydroxide heated to give magnesium oxide / $Mg(OH)_2 \rightarrow MgO + H_2O$
ANY FOUR: (4 x 3)

equation (lime + seawater): **$Ca(OH)_2 + MgCl_2 \rightarrow Mg(OH)_2 + CaCl_2$** (3)
<u>Note</u>: the word points cannot be got from the equations except in cases where the names are written under them.

B (i) **Aughinish / Shannon estuary / Limerick / Askeaton / Foynes / Other suitable places** (4)

(ii) **$Al_2O_3.3H_2O + 2NaOH \longrightarrow 2NaAlO_2 + 4H_2O$ /**
$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$ /
$Al(OH)_3 + 2NaOH \longrightarrow 2NaAlO_2 + 2H_2O$ (3)

reaction (digestion, dissolving) with sodium hydroxide to produce sodium aluminate /

filtration (clarification) to remove impurities / precipitation of (seeding to produce)
$Al_2O_3.3H_2O$ / $2NaAlO_2 + 4H_2O \longrightarrow Al_2O_3.3H_2O + 2NaOH$
removal of water (dehydration, calcination) / by heating (roasting, temp
of around 1000 ^oC on arrow) / $Al_2O_3.3H_2O \longrightarrow Al_2O_3 + 3H_2O$ ANY FOUR: (4 x 3)

(iii) **saves energy / cheaper / avoids litter / reduces (limits) environmental damage /**
prevents loss of aluminium (conservation of natural resources) ANY TWO: (2 x 3)