Coimisiún na Scrúduithe Stáit
State Examinations Commission

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Ceimic *Ardleibhéal*

Marking Scheme *Leaving Certificate Examination, 2004*

Chemistry *Higher level*

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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. 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) Name 4, Col. Change 4; (b) Describe $6 + 3 \times 3$; (c) Solution 3, 3;
(d) Calculate (i) 9, (ii) 3, (iii) 3; (e) Equation: formulas 3, balancing 3.

2. (a) Function 5, Identify 3, Describe 3; (b) Precautions $2 \times (2 \times 3)$; (c) Equation 6;
(d) Unsatd. 3, Test 3×3; (e) Flame 3, Equation: formulas 3, balancing 3

3. (a) (i) 5, (ii) Insoluble 2×3, Soluble 2×3; (iii) 3, (iv) 3, (v) 3;
(b) (i) $6 + 3 \times 3$, (ii) 2×3, (iii) (3).

Section B

4. **<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.**

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

5. (a) Config. 5, Diagram 3, Describe 2×3, Type 3, 3;
(b) Define 3×3, State 3, 3, Account 2×3, Explain 6 or 2 x 3, 3.

6. (a) (i) 5, (ii) 6; (b) Calculate 12; (c) Properties 2 x 3, Why 3; (d) Outline $6 + 2 \times 3$; (e) Identify 2×3.

7. (a) Identify 2×4; (b) Names & Type One point 6, two points 12, three points 15 ; (c) (i) – (iv) First correct point 6, other five points 5 x 3; (d) Uses ANY TWO: (2 x 3)

8. (a) Define 5, Explain 3; (b) Name A 3, B 3, Copy 2×3; (c) Elements 2×3, Poison 3;
(d) Observe 4×3, Explain 2×3.

9. (a) Equil. 5, Dynamic 3; (b) Predict 3, 3, Reason (i) 3, (ii) 3; (c) Are 3, Explain 3;
(d) Effect 6; (e) K_c 6, Calc. 12.

10. (a) (i) 10, (ii) 9, (iii) 6.
(b) Describe $4 + 3 \times 3$, (i) 2×3, (ii) 3, (iii) 3.
(c) State 3, 2; (i) 3, 2, (ii) 3, (iii) 12.

11. (a) Define 2×3, (i) 2×3, (ii) 6, (iii) 3, 4.
(b) Define 7, (i) 2×3, (ii) 12.
(c) A (i) 4, (ii) 3; Type 3, Forces 3, Explain (i) 2×3, (ii) 2×3.
B (i) 4, 3, (ii) 3, (iii) 3, (iv) 3, (v) 3×3.

SECTION A

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

QUESTION 1

(a) NAME: **eriochrome black T (solochrome black)** (4)
[Accept *eriochrome or eriochrome T; likewise for solochrome*]
COL. CHANGE: wine **red (wine) to** deep **blue** [*Given independently of NAME*] (4)

(b) DESCRIBE:
rinse with deionised water
rinse with reagent (solution)
clamp vertically
use funnel when adding reagent **/ remove funnel** after filling
open tap to fill below tap (tip, jet, nozzle) / remove air bubbles [*Allow 'tap is full'*]
set bottom of meniscus on mark / read bottom of meniscus ANY FOUR: (6 + 3 × 3)

(c) SOLUTION: **buffer** (3)

to keep pH above 9 / to keep pH at (around) 10 / ensure sharp (accurate) end-point (3)
[Accept *'to keep pH at a certain value (from changing)']*

(d) CALCULATE: (i) **0.00081** mol l^{-1} (9)

$\frac{100 \times X}{1} = \frac{8.1 \times 0.01}{1}$ / $100 \times X = 8.1 \times 0.01$ (6)

$X = 0.00081$ (3)

(ii) **0.081** g l^{-1} (3)

$0.00081 \times 100^{*} = 0.081$ (3)
[**100 essential unless calculation shown e.g. 40 + 12 + 3 x 16 = 98 (slip)*]

(iii) **81** p.p.m. (3)

$0.081 \times 1000 = 81$ (3)

(e) EQUATION: $\mathbf{CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2}$ /
$\mathbf{CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2CO_3}$ Formulas (3) Balancing (3)

QUESTION 2

(a) FUNCTION: **keeps (holds, soaks up) ethanol (liquid, reagent) at end of test tube / avoid wetting the aluminium oxide** (5)

IDENTIFY: **aluminium oxide / alumina / Al_2O_3** (3)

DESCRIBE: **white** powder (solid) [*Given independently of IDENTIFY*] (3)
[*Do not allow grey or other colours*]

(b) PRECAUTIONS: **first precaution** (3) **explanation** (3); **second precaution** (3) **explanation** (3)

keep gas away from flames (3) gas is flammable / risk of explosion (3)
air-tight stopper (secure assembly) (3) stops ethene escaping / prevents fire (explosion) (3)
safety screen (glasses) (3) risk of explosion (3)
taking tube from water / disconnecting tube / dismantling (3) to prevent suckback (3)
tongs (gloves, glass rod) (3) skin sensitive to glass wool (3)
avoid inhalation of glass wool (wear mask) (3) glass wool a lung irritant (3)
tongs (heat resistant gloves) (3) prevent burns (can be inferred here) (3)
Must be matched
[*Accept general procedural precautions for 3 marks only e.g. 'heat gently at first', 'take care in inserting glass tubing in bungs', 'heat Al_2O_3 directly', 'don't heat ethanol with naked flame'*]

(c) EQUATION: $\mathbf{C_2H_5OH \longrightarrow C_2H_4 + H_2O}$ / $\mathbf{C_2H_5OH \xrightarrow{Al_2O_3} C_2H_4 + H_2O}$ (6)

Allow: $C_2H_5OH - H_2O \longrightarrow C_2H_4$
$C_2H_5OH \xrightarrow{-H_2O} C_2H_4$ [Accept *if written with + H_2O*]
$C_2H_5OH + Al_2O_3 \longrightarrow C_2H_4 + H_2O + Al_2O_3$

[Allow *(3) for correct formulas of <u>both</u> ethanol and ethene as reactant and product*]

(d) UNSATD: **double / triple / multiple bond** (carbon-to-carbon bond) **present / undergoes addition reactions** (3)

TEST: add **bromine** water (solution) (3) **add (bubble through, shake with)** (3)

red / orange / yellow (3) OR **bromine** water (3)
[Accept *'red-brown' but not 'brown'*]
to colourless (3) **decolorises** (*not 'goes clear'*) (3)

(e) FLAME: **yellow / luminous (bright)** / slightly **smoky (sooty)** flame (3)
[*'clean' not acceptable but does not cancel a correct answer*]

EQUATION: $\mathbf{C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O}$ Formulas (3) Balancing (3)

QUESTION 3

(a) (i) **so that crystals will form on cooling / so that benzoic acid does not remain in solution on cooling / to maximise yield / to minimise what stays dissolved** in the solvent / **so that** hot **solution is saturated / keep solution as concentrated as possible** (5)
[Allow '*concentrated' for 3 marks only*]

(ii) *insoluble*: **filtration of hot solution / first filtration** (3)
remained on filter paper (in funnel) / not able to pass through (3)

soluble: **filtration of recrystallised benzoic acid / cold filtration / second filtration** (3)
passed through filter paper (funnel) / stayed in (retained by) mother liquor (solution, filtrate) (3)

(iii) let solution **cool fully (efficiently)** / **cool in ice-water (crushed ice) / evaporate more solvent (water)** [Accept check if m.p. is sharp] (3)

(iv) leave **in warm place (on radiator) / in desiccator / in oven** at 100 ^{o}C (3)
[Accept *'leave on filter paper (air dry)', also a specified suitable warm place.*]

(v) **90** % (3)

$$\frac{2.25}{2.5} \times 100 = 90 \quad (3)$$

(b) (i) **correct diagram with instrument for measuring temperature including one valid label**

melting point apparatus with thermometer
thiele tube (beaker) containing liquid with thermometer
aluminium block with thermometer (temp. probe labelled if used)

detail of setting up

sample in melting point tube for melting point apparatus and thiele tube (beaker)
sample on aluminium block or in melting point tube for aluminium block
[*Stated or labelled in diagram*]

method of heating *

electrical in melting point apparatus
bunsen (hotplate) and suitable liquid (e.g. liquid paraffin / oil) for thiele tube (beaker)
bunsen (hotplate) for aluminium block
[*Can be got if shown on diagram – even if unlabelled*]

heat slowly (gently)*

observe (note) the substance as it is heated*

note **temperature (range) at which it melts** FOUR POINTS: (6 + 3 x 3)

***** *Accept only two from these three points*

(ii) **lower** (3)

less sharp / melting over wider (broader) range of temperatures (3)

(iii) **preservative (E2--) / disinfectant (antiseptic, biocide, fungicide) / calibration of thermometers** for melting point apparatus (3)

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) **average mass of atoms** of element (3) **relative to (based on)** $^{1}/_{12}$ mass of **carbon-12** atom (3)

(b) **NH_3 has three bond pairs and one lone pair** (shown/stated) (3) **BF_3 has three bond pairs** (shown/stated)(3)
[Allow *ammonia has a lone pair of electrons for 6 marks*]

(c) *oxygen*: / **Stronger intermolecular (Van der Waals', London, dispersion, dipole-dipole) forces** (6)
[Allow *higher molecular mass or bigger electron cloud (more electrons) for 3 marks only*]
[*or opposite points for hydrogen*]

(d) **volume varies directly with kelvin (absolute) temperature** / $^{V}/_{T^*} = k$ / $^{V_1}/_{T_1} = {}^{V_2}/_{T_2}$ / $V \propto T$ /
rate of expansion of a gas is $^{1}/_{273}$ of its volume at 0 °C for every degree Celsius rise in temperature (3)
for a definite **mass** of gas at **constant pressure** * must be capital letter. (3)

(e) (i) **$H_2PO_4^-$** (3) (ii) **PO_4^{3-}** (3)

(f) **precipitation / tertiary treatment** [Accept coagulation or flocculation] (6)
[Accept *a suitable precipitating agents for 3 marks only*]

(g) (i) **– 1** (3) (ii) **+ 5 / 5** / V (3)

(h) **70** % [*No penalty incurred if A_r values from Periodic Table used*] (6)

$\frac{112}{160}$ (3) × 100 = 70 (3)

(i) *State*: **purple (violet, pink)** (3)
Explain: **hydroxyl ions produced / pH increases** around (near) electrode / **alkaline** (3)

(j) white **precipitate (cloudiness) with barium chloride (barium nitrate, barium ions)** solution (3)
which **dissolves (disappears) in** dilute **hydrochloric acid (HCl)** [*Given independently of reagent used*] (3)

(k) **A** **liquefaction / fractional distillation / using diffusion** (3) **of air** (3)
electrolysis of (3) acidified **water** (3)

B **thickens (thick)** protective **layer** (3) **of oxide** on surface (3)

QUESTION 5

(a) CONFIG: **$1s^2 2s^2 2p_x^1 2p_y^1 2p_z^1$** (5)
[*Allow (5) for $1s^2 2s^2 2p^3$*]

DIAGRAM: 

/ :N⋮⋮N: / :N:::N: / :N⋮≡⋮N: (3)

[*Accept diagrams as above with all dots or all crosses*]

DESCRIBE: **one** sigma (σ) (3) **two** pi (π) (3)
[*No marks for* two *and* one *unless names (symbols) given*]

TYPE: **Van der Waals / London / Dispersion / Dipole-dipole** (3)

molecule is **non-polar / pure covalent / temporary (non-permanent, transient forces) / due to temporary distortion of the electron cloud** (3)

(b) 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** (3)

STATE: **increase in nuclear charge (atomic number)** (3) **decrease in atomic radius** (3)

ACCOUNT: **nitrogen stable** (3)

due to **half-full** p **sublevel (subshell) /** due to **three half-full p orbitals /** due to $1s^2 2s^2$**$2p^3$ /** due to **$2p_x^1 2p_y^1 2p_z^1$** (3)

OR

oxygen less stable (3)

due to **pair of electrons in one p orbital /** due to $1s^2 2s^2$**$2p^4$ /** due to **$2p_x^2 2p_y^1 2p_z^1$ / one electron away from stable (loss of electron makes stable)** (3)

EXPLAIN: *sodium*: **First electron removed from third (outer, 3**s**) shell (level) whereas second removed from second (inner, 2**p**) shell (level)** (6)

loss of **first gives high stability configuration [full outer level (full outer shell), noble gas (Ne) configuration, outer (stable) octet ($2s^2 2p^6$)]** (3)
loss of **second from high stability configuration [new(inner) level (shell), full level (full shell), noble gas (Ne) configuration, outer (stable) octet, $2s^2 2p^6$ (***not full 2p***)]** (3)

Neon: **second from same** sub**level (**sub**shell) / first removed from full (stable) shell (level) and second removed from same shell (level) / both removed from 2**p (3)

QUESTION 6

(a) (i) heat (energy) when **1 mole** //of compound **formed from** its **elements** (3 + 2)

(ii) **measure of (indication of, showing, giving) tendency (likelihood) to auto-ignite (knock, pink, pre-ignite, ignite early, ignite before spark) /** number **representing ability of fuel to resist auto-igniting (knocking, pinking, pre-igniting, igniting early, igniting before spark)** (6)

or

based on a scale where 2,2,4-trimethylpentane (*iso*-octane) is assigned a rating of 100 and heptane (*n*-heptane) a value of 0. (6)

or

Percentage by volume of 2,2,4-trimethylpentane (*iso*-octane) in a blend (mix) with heptane (*n*-heptane) that matches the behaviour of the fuel in terms of auto-ignition (6)

(b) CALC.: **– 75.6** kJ mol^{-1} (12)

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

$C + O_2 \rightarrow CO_2 \quad \Delta H = \mathbf{-394} \text{ kJ}$ (3)

$2H_2 + O_2 \rightarrow 2H_2O \quad \Delta H = \mathbf{-572} \text{ kJ}$ (3) [*Equations not required*]

$CO_2 + 2H_2O \rightarrow CH_4 + 2O_2 \quad \Delta H = \mathbf{890.4} \text{ kJ}$ (3)

$C + 2H_2 \rightarrow CH_4 \quad \Delta H = \mathbf{-75.6} \text{ kJ mol}^{-1}$ (3)

OR

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

$\mathbf{-890.4}$ (3) $= [\mathbf{-394}$ (3) $\mathbf{-572}$ (3)$] - [\Delta H_{f(methane)} + 0]$

$\Delta H_{f(methane)} = \mathbf{-394 - 572 + 890.4} = \mathbf{-75.6} \text{ kJ mol}^{-1}$ (3)

[Allow *3 marks only for +75.6 kJ mol^{-1}*]

(c) PROPS: **high** kilogram **cal. value (high energy output, high heat of combustion) / clean (non- polluting, burns to produce carbon dioxide and water) / non-toxic / plentiful /** relatively **cheap/ can be piped (easily distributed)** [Do not accept *'easily distributed in tanks'*] ANY TWO: (2 x 3)

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

(d) OUTLINE: **crude oil heated (evaporated) / crude added continuously at bottom**

vapour (gas) **passes up through tower (column) / fractionating tower with trays**

fractions condense (separate, taken off) at different levels (up along tower)

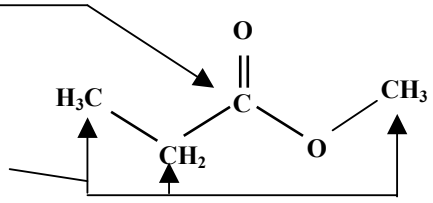
depending on their boiling points / high b.p. fractions at bottom / low higher up / heavier at bottom / lighter at top / or named exemplar to indicate this ANY THREE: (6 + 2 x 3)

[*The first three points can be got from a diagram; the last point must be specified in words or clearly written on the diagram.]*

(e) IDENTIFY: **chain length / branching / rings (cyclic) / aromatics** ANY TWO: (2 x 3)

QUESTION 7

(a) IDENTIFY: **planar carbon** (4)



tetrahedral carbon ANY ONE TETRAHEDRAL: (4)

(b) NAMES: *alcohol*: **methanol (methyl alcohol)** [*Name essential*]

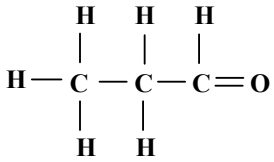
carboxylic acid: **propanoic acid (propionic acid)** [*Name essential*]

TYPE: **substitution / condensation / dehydration** (2 x 6 +3)

(c) (i) **propan-1-ol / 1-propanol / propyl alcohol / *n*-propanol / correct formula**
[Accept propanol]

(ii) **propanal (propionaldehyde)** [*Allow propan-1-al*]

CH_3CH_2CHO / C_2H_5CHO /



(iii) **oxidation / redox / dehydrogenation and oxidation**
[*No marks for 'dehydrogenation' on its own*]

(iv) **sulfuric acid (H_2SO_4) / acidified / H^+**

sodium (potassium) **dichromate (chromate)** (VI) / potassium **manganate** (VII) / potassium **permanganate / correct formula**

(6 + 5 x 3)

(d) USES: **perfumes (scents) / cosmetics / flavourings (essences) / soap making / drugs (aspirin, paracetamol, amyl nitrite, etc.) / anaesthetics (novocaine, benzocaine, etc.) / insecticides (malathion, pyrethrin, etc.) / clothing (named item) / sails / seat belts / plastics (perspex) / rubs (oil of wintergreen) / solvents for (production of) varnishes (lacquers, enamels, adhesives, glues, paints, inks, etc.) / energy storage / lowering cholesterol / aromatherapy / synthetic fibres / cooking / soap** ANY TWO: (2 x 3)

QUESTION 8

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

$$\frac{\textbf{change in concentration}}{\textbf{time}}$$

[*Do not accept 'mass', 'volume', 'quantity', 'amount' in place of concentration*] (5)

EXPLAIN: **More (greater number of) collisions reach (excede) activation energy /more collisions have enough energy for reaction / more effective collisions** (6)
[*Allow (3) for 'greater number of high energy collisions','increases energy (velocity, speed) of particles (molecules, reagents, collisions)' or 'more collisions' or 'more molecules have the activation energy']*

(b) NAME: A: **Activation energy** [Accept E_a or E_{act}] (3)

B: **Heat of reaction / Heat change / ΔH / Heat absorbed / Enthalpy change** (3)
[Accept *'energy' for 'heat'*]

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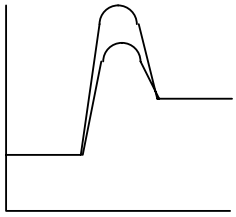


Reduction in activation energy shown (3)

Products line shown above reactants line / same ΔH with and without catalyst (3)

(c) ELEMENTS: **platinum / palladium / rhodium** [*Allow symbols*] ANY TWO: (2 x 3)

POISON: **lead [lead compounds e.g tetraethyllead (TEL)] / sulfur (sulfur cpds.)** [*Allow symbols*] (3)

(d) OBSERVE: **pink at start** of reaction [*Accept red*] (3)

then **bubbling (effervescence, fizzing, gas produced)** as (3)

reaction mixture **turns green** (3)

reaction finishes and mixture **turns pink again** (3)

EXPLAIN: **Colour change (change from pink to green) indicates formation of new substance**
[*Can be got under OBSERVE if clear*] **Change back to original colour (pink) suggests it is an intermediate**
Bubbling while green suggests intermediate is reacting ANY ONE: (6)
[Accept *Changes colour and changes back indicates intermediate* (6)]

QUESTION 9

(a) EQUIL: state in which **rate of forward reaction = rate of reverse (backward) reaction** (5)
[Allow 5 marks for $R_f = R_{rev}$]

DYNAMIC: reaction has **not stopped / reaction continuing /**
product forming and returning to reactants constantly (3)

(b) PREDICT: **low** temperature (3) **high** pressure (3)

OR **high pressure** (3) and **low temperature** (3)

REASON: (i) forward (ammonia producing) **reaction is exothermic (produces heat, raises temp.)** (3)

(ii) forward (ammonia producing) **reaction** goes to **fewer molecules (smaller volume, alleviates or lowers pressure)** (3)
[*Marks for (i) and (ii) can be given independently of PREDICT*]

(c) ARE: **No / high temperature is used [/ compromise temperature / specified high temperature]** (3)

EXPLAIN: at low temperatures **rate is too low (slow) / activation energy too high** (3)

(d) EFFECT: **lowers activation energy / increases rate for both / catalyses both /**
reaches equilibrium faster / **equilibrium** position **unaffected /**
forward and reverse rates equally affected (6)
[Allow *3 marks only for 'increases rate'*]

(e) K_c: $\dfrac{[NH_3]^2}{[N_2][H_2]^3}$ (6)

CALC: **0.4** $l^2\ mol^{-2}$ (M^{-2}) [*or answer that rounds off to 0.4*] (12)

	N_2	+	$3H_2$	$\rightleftharpoons$	$2NH_3$	
	6 mol		18 mol		0 mol	
	3 mol		9 mol		6 mol	(3)
÷ 5	0.6 *M*		1.8 *M*		1.2 *M*	(3)

$K_c = \dfrac{(1.2)^2}{(0.6)(1.8)^3}$ (3) = 0.4 (3)

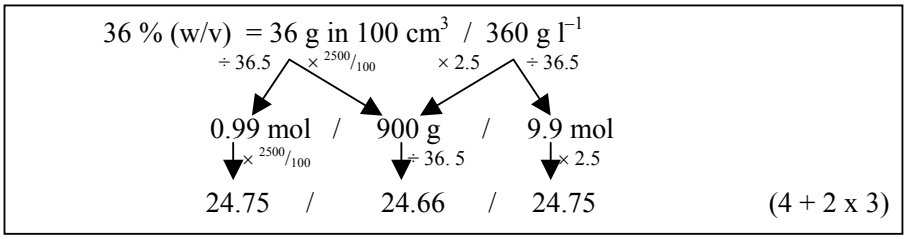
OR

	N_2	+	$3H_2$	$\rightleftharpoons$	$2NH_3$	
	6 mol		18 mol		0 mol	
÷ 5	1.2 *M*		3.6 *M*		0 *M*	(3)
	0.6 *M*		1.8 *M*		1.2 *M*	(3)

$K_c = \dfrac{(1.2)^2}{(0.6)(1.8)^3}$ (3) = 0.4 (3)

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

(a) (i) MOLES: Allow **24.60 to 25.00** mol (10)



(4 + 2 x 3)

(ii) Allow **1303.80 to 1325.00** g (9)

24.60 to 25.00 mol HCl ≡ 12.30 to 12.50 mol Na_2CO_3 (3)

12.30 to 12.50 x 106* = 1303.80 to 1325.00 (6)

[**106 essential unless calculation shown e.g. = 2* x *23 + 12 + 3* x *16 = 107 (slip)*]

(iii) Allow **295.20 to 300.00** (6)

24.60 to 25.00 mol HCl ⟶ 12.30 to 12.50 mol CO_2 (3)

12.30 to 12.50 x 24 = 295.20 to 300.00 (3) [*Give (0) if 22.4 used*]

(b) DESCRIBE: **electrons in ground state / electrons restricted to energy levels (energy values, discrete energies) / energy level diagram / energy of electron quantised** (4)

fixed energies (photons) absorbed / jump (move, promoted) to higher level(s) (excited state) / energy only emitted (absorbed) when electrons move between fixed levels (3)

excited state unstable / electrons **fall back to lower levels /** electrons **fall back emitting energy as light (electromagnetic energy, photons) / emitting discrete packets (photons) of energy** (3)

energy difference between levels gives specific (definite) frequency (wavelength, line) of light in spectrum **/ energy of photons dictated by energy gap between levels / $E_2 - E_1$ = hν (hf)** (3)

(i) **each element has a different distribution (set, arrangement) of energy levels / different electron configurations** (3)
giving rise to **different electron transitions** (3)

[Allow *due to* ***different numbers of electrons and nuclear charge / different attractions between electrons and nucleus (different electrostatic attractions)*** for 3 marks only]

(ii) **atomic absorption spectrometry (AAS)** [*Accept the spelling 'absor<u>b</u>tion*] (3)

(iii) **only worked for simple (hydrogen, hydrogen-like) species (atoms) / wave nature of electron (wave-particle duality) / Heisenberg uncertainty principle (or its statement) / discovery of sublevels (subshells) / could not explain Zeeman effect / didn't explain splitting of lines** (3)

Question 10 continued/

(c) STATE: **equal (same) volumes of gases contain equal (same) numbers of molecules (particles, moles)** (3)
under same conditions of temperature and pressure (2)
[Allow *'1 mole of a gas occupies 22.4 l at stp for 3 marks only'*]

(i) perfectly **obeys the gas laws (Boyle's law, the kinetic theory, PV = nRT)** (3)
under all conditions of temperature and pressure (2)

(ii) **polar / intermolecular forces (attractions between molecules, named intermolecular force) / molecules have volume (volume of molecules not negligible) / collisions not perfectly elastic** ANY ONE: (3)

(iii) **0.12** litres (12)

$PV = nRT \Rightarrow V = \frac{nRT}{P}$ $\quad T = 20 + 273 = 293$ K $\quad P = 101 \times 1000 = 1.01 \times 10^5$ Pa

$n = \frac{0.29}{58} = 0.005$ mol (3)

$V = \frac{0.005 \times 8.3 \times 293}{1.01 \times 10^5}$ (3) $= 0.00012\ m^3$ (3)

$0.00012 \times 1000 = 0.12$ litres (3)

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

(a) DEFINE: spontaneous (random) **emission of radiation (radiant energy, rays)** (3)
[Accept *'...of α, β and γ particles' but not '...particles' on its own*]
from unstable nuclei / [Allow *due to disintegration (breaking up, decomposition) of nuclei*] (3)

(i) **negative (minus**) charge **/ negligible (around $^1/_{1840}$ or 0.00054) mass / high speed / more penetrating than α (less penetrating than γ, stopped by 2 – 5 mm (sheet of) aluminium, moderately penetrating) / less ionising than α (more ionising than γ, moderately ionising) / damage** body **cells (cause cancer) / electrons** from nucleus **/ deflected by electric fields / deflected by magnetic fields /fluorescence / phosphorescence** ANY TWO: (2 x 3)

(ii) $^{14}_{6}\mathrm{C} \longrightarrow {}^{0}_{-1}\mathrm{e} + {}^{14}_{7}\mathrm{N}$ [*Allow with atomic numbers on top and mass numbers below but not mixed*] (6)

[*Allow (3) for identifying nitrogen as a product*] [*Allow* $^{0}_{-1}\beta$ *for* $^{0}_{-1}e$]

(iii) **In living things, the ratio of carbon-12 to carbon-14 is constant (same as in air)** (3)
[Accept *'C-14 constant during life' or 'C-14 replaced (taken in) during life'*]
After death, carbon-14 decays and the changed **ratio and the half-life used** to find age /
decrease in carbon-14 related to time passed since death (4)

Question 11 continued/

(b) DEFINE: **minus log (negative log)** to base 10 **of the hydrogen (hydronium) ion concentration / $-\log_{10}[H^+]$ / $-\log_{10}[H_3O^+]$ / $\log_{10}\frac{1}{[H^+]}$ / $\log_{10}\frac{1}{[H_3O^+]}$** (7)

(i) **dilute solution (does not work in concentrated solutions) / aqueous solution / 25 °C (298 K) / 0 – 14 / does not work at extremely low concentrations** ANY TWO: (2 x 3)

(ii) **2.43 / 2.4** (12)

4.5 g /100 cm^3 $\xrightarrow{\times 10}$ 45 g l^{-1} (3) $\xrightarrow{\div 60}$ 0.75 mol l^{-1} (3) [dividing by 60 first is valid]

pH = $-\log \sqrt{K_a.M}$ / $-\log \sqrt{1.8 \times 10^{-5} \times 0.75}$ (3) = 2.43 / 2.4 (3)

OR $[H^+]^2 = K_a.M$ $(1.8 \times 10^{-5} \times 0.75)$ / $[H^+] = \sqrt{K_a.M}$ $(\sqrt{1.8 \times 10^{-5} \times 0.75})$ (3) pH = 2.43 / 2.4 (3)

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

A (i) developed **x-ray crystallography (x-rays to find crystal structure)** (4)

(ii) used x-rays to **find structure of complex molecules {penicillin, vitamin B_{12} (cobalamin)}** (3)
[Accept *'large', 'big', 'complicated' for 'complex'*]

TYPE: covalent **molecular** (3)

FORCES: **Van der Waals' / London / dispersion / dipole-dipole** (3)

EXPLAIN: (i) **outer (valence) electrons** (3)
delocalised / can move easily through the crystal (3)

(ii) attraction of surface ions in crystal for **polar water** molecules (3)
overcomes (stronger than) attractions between ions (ion-ion attractions) in crystal / **attracts (hydrates, solvates) the ions** in the crystal (3)
[*Can be got from clear diagram showing correct charges*]

B (i) **blocking (preventing escape, absorption or reabsorption) of radiation (heat, energy, infra-red)** (4)
by gases in **the atmosphere** (3)

(ii) **carbon dioxide (CO_2) / methane (CH_4) / chlorofluorocarbon (CFC) / oxides of nitrogen (NO_x) water (H_2O)** [Accept *ozone*] (3)

(iii) *carbon dioxide*: **fossil fuel combustion / respiration / deforestation / aerosols / car exhausts**
methane: **paddy fields (rice growing) / ruminants (cows, sheep, etc., anaerobic digestion) / landfill (dumps) / natural gas leakage**
chlorofluorocarbon: **refrigeration / aerosol** propellants **/ foams / fire extinguishers**
nitrogen oxides: **car exhausts / nitrogenous fertilisers**
water: [Accept *fossil fuel combustion / evaporation / transpiration / perspiration (sweating) / excretion /respiration / car exhausts*]
ozone: [Accept *welding /photocopiers*] ANY ONE: [*Must correspond with answer given in (ii)*] (3)

(iv) **nitrogen (N_2) / oxygen (O_2) / any identified noble gas (name or formula)** (3)

(v) **global warming (increase in temperature** of Earth) / **rise in sea level / melting polar ice / changing climate / drier Summers / wetter Winters / drought / floods / earlier planting / earlier harvesting / lower fertiliser need / increased irrigation / increased plant (animal) diseases / change in crop suitability / extinction of some species / increased carbon dioxide / increased methane / migration of species (birds, etc.)** ANY THREE: (3 x 3)