Coimisiún na Scrúduithe Stáit

State Examinations Commission

Leaving Certificate Examinations 2006

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) Identify 5; (b) Name 3, 2 x 3, Explain 3; (c) (i) Describe 2 x 3, (ii) Why 6;
(d) (i) Moles per litre 6, (ii) Grams per litre 3; (e) Calculate (i) 3, (ii) 9.

2. (a) Why 5, Type 3; (b) Complete 2 x 3, Balance 3; (c) What 3, Why 3, Describe 6;
(d) Describe 6, 3; (e) Location (i) 3, (ii) 3; (f) Observe (i) 3, (ii) 3.

3. (a) What 2 x 4; (b) Identify 3, Colour 3; (c) Describe 12; (d) Species 6, Give 3;
(e) (i) 9, (ii) 6.

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

5. (a) (i) Describe 2 x 4, (ii) Why 3, 3, (iii) What 3, (iv) Define 6, (v) What 2 x 3.
(b) (i) Define 3, 3, (ii) Explain 2 x 3, (iii) 6, 3.

6. (a) (i) What 8, (ii) What 3, (iii) Identify 3, 3, 3, (iv) Process 3, Why 3.
(b) (i) Give 2 x 3, (ii) Give 2 x 3. (c) 12.

7. (a) Define 5; (b) Give 3, 3, Which 3, Why 3; (c) Describe 3, 3, 3, 3; (d) When 6;
(e) Type 3, Give 2 x 3, 2 x 3.

8. (a) (i) What 5, (ii) Explain 2 x 3, (iii) What 2 x 3, Name 3, (iv) What 3, Why 3.
(b) (i) Explain 3, 3, 3, (ii) Draw 3, 3, 3, (iii) Explain 6.

9. (a) What 5; (b) (i) Name 3, Formula 3, (ii) Identify 3, (iii) What 3, Why 3, (iv) Give 3;
(c) Describe 3 x 3, State 3, Explain 3; (d) Draw 4 x 3.

10. (a) (i) What 4, (ii) Define 2 x 3, (iii) What 3 x 3, (4) Calc. 6.
(b) Define 4, What (i) 3, (ii) 3, State 3, Explain 3, Identify 3, Colours 3, 3.
(c) (i) Give 4 + 3, (ii) Explain 6, (iii) Describe 4 x 3.

11. (a) (i) What 4, (ii) Give 3, (iii) Moles 9, (iv) Molecules 3, (v) Mass 6.
(b) State 4 + 3, (i) When 3, Explain 3, (ii) State 3, Explain 3, (iii) How 6.
(c) A (i) What 2 x 3, Describe 2 x 3, (ii) Name 3, (iii) State 6, What 4.
B (i) What 4 x 3, (ii) Name 3, Equation 2 x 3, (iii) Why 4.

SECTION A

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

QUESTION 1

(a) IDENTIFY: **anhydrous sodium carbonate (Na_2CO_3)** [Allow (3) for *sodium carbonate*.] (5)

[*OTHER POSSIBILITY*: sodium tetraborate (disodium tetraborate, $Na_2B_4O_7$)]

(b) NAME: **indicator** (3)

colour change (2 × 3)

methyl orange	orange (yellow)	//	to red (pink)
methyl red	yellow	//	to red (pink)
methyl yellow	yellow	//	to red (pink)
bromophenol blue	blue (purple, violet)	//	to yellow
bromocresol green	blue	//	to yellow

[*Colour change must be matched with chosen indicator*]

EXPLAIN: **indicator is a** weak **acid / indicator is a** weak **base** (3)

(c) (i) DESCRIBE: **rinse with deionised (distilled) water //**

rinse with reagent (solution) (2 × 3)

(ii) WHY: **air will be displaced by the solution (reagent) / some of measured volume replaces air / some of measured volume not delivered / some of measured volume goes to fill space / causes (gives) wrong (inaccurate, too high, too low) reading (result, titre) / air will be displaced (removed, got rid of)** during the titration **/ will be filled during the titration / affects result /** burette **only works properly when it** (part below tap) **is full /** burette **designed to work properly when it** (part below tap) **is full / distorts result (reading)** [Accept 'air bubbles' for 'air'] (6)

(d) (i) MOL/LITRE: **0.05731 / 0.0573 / 0.057** M **[0.06 (-1)*]** (6)

$$\frac{25 \times X}{1} = \frac{26.05 \times 0.11}{2} \quad (3)$$

X = 0.05731 / 0.0573 / 0.057 M (3)

*Not deducted if more accurate value also given. However, lost later if 0.06 used in later calculations.

(ii) g/LITRE: **6.042 to 6.075** g l^{-1} (3)

$$0.0573 \times 106^* = 6.075 \quad (3)$$

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

QUESTION 1 continued:

(e) CALCULATE: (i) **62.9 to 63.2%** (3)

$$\frac{10.325 \times 100}{16.4} = 62.9 \quad (3)$$

(ii) **10** [*Accept answers giving 10 when rounded off to nearest integer*] (9)

M_r of Na_2CO_3 = 106	M_r of H_2O = 18

hydrated form = 8.20×2 = 16.4 g l^{-1}
water content = 16.4 – 6.075 = 10.325 (3)

$^{6.075}/_{106}$: $^{10.325}/_{18}$ (3)

0.0573 : 0.573

1 : 10 (3)

OR

anhydrous form = 6.075 ÷ 2 = 3.0375 g/500cm^3
water content = 8.20 – 3.0375 = 5.1625 (3)

$^{3.0375}/_{106}$: $^{5.1625}/_{18}$ (3)

0.0287 : 0.287

1 : 10 (3)

OR

hydrated form = 16.4 g l^{-1} => $M_r = {}^{16.4}/_{0.05731} = 286$ (3)
water content = 286 – 106 = 180 / 286 = 106 + 18x (3)
=> x = 180 ÷ 18 = 10 (3)

OR

hydrated form = 16.4 g l^{-1} $^{Mr}/_{106} = {}^{16.4}/_{6.075}$ => M_r = 286 (3)
water content = 286 – 106 = 180 / 286 = 106 + 18x (3)
=> x = 180 ÷ 18 = 10 (3)

OR

hydrated form = 16.4 g l^{-1} => water = 16.4 – 6.075 = 10.325 g (3)
$^{water}/_{106} = {}^{10.325}/_{6.075}$ => water = 180 (3)
=> x = 180 ÷ 18 = 10 (3)

OR

anhydrous form = 3.0375 g/500cm^3 water = 8.2 – 3.0375 = 5.1625 g (3)
$^{water}/_{106} = {}^{5.1625}/_{3.0375}$ => water = 180 (3)
=> x = 180 ÷ 18 = 10 (3)

[Note: If no marks have been got in (e) (ii), 3 marks to be awarded if M_r of Na_2CO_3 (106) appears in the candidate's calculations.]

QUESTION 2

(a) WHY: **to speed up** the reaction / reaction **is slow** / **to drive** reaction **to completion / to maximise (increase) yield** [Allow even if incorrect reaction specified]
[Allow '*to prevent loss of vapour (ethanol, solvent)*] (5)

TYPE: base **hydrolysis / saponification** [Accept *substitution*] (3)

(b) COMPLETE: ⟶ **$C_{17}H_{35}COONa$ + $CH_2(OH)CH(OH)CH_2OH$** [*Accept without brackets*] (2 × 3)

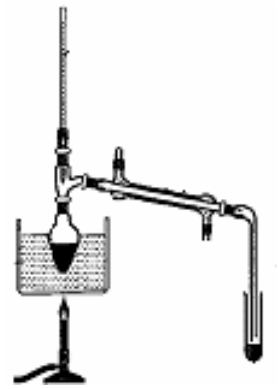
BALANCE: ⟶ **3** $C_{17}H_{35}COONa$ + $CH_2(OH)CH(OH)CH_2OH$ (3)

[Accept *full structures* (Accept *bonds without Hs*)*, also molecular formulas*: $C_{18}H_{35}O_2Na$ *and* $C_3H_8O_3$]
[Give *balancing marks even if both formulas are incorrect*.]

(c) WHAT: **solvent** (3)

WHY: **easier to isolate (extract) 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** (3)

DESCRIBE: **diagram showing any <u>two</u> from the box and one correct label** (6)



strong heat (Bunsen, hot plate) & thermometer (positioned correctly) / gentle heat (water bath, isomantle) //

still head / distilling flask //

condenser (sloping down, showing inlet & outlet for water) //

collection in vessel (adaptor not required)

[Diagram with any two from the box and no correct label (3)]

[If no marks got for diagram, (3) may be given for '*heat gently until 20 to 25 cm^3 ethanol collected*'. To get this (3) there <u>must</u> be a diagram of some sort.]

(d) DESCRIBE: **dissolve residue in minimum of boiling (hot) water / add in a little boiling (hot) water** //
pour onto brine (salt water, sodium chloride solution) //
filter //
wash with more **brine / wash with** a little **ice-water** POUR INTO BRINE (6) ONE OTHER POINT (3)

(e) LOCATION: (i) *second product*: **in the filtrate / in the brine** / **Buchner flask** (3)

(ii) *excess sodium hydroxide*: **in the filtrate / in the brine / Buchner flask** (3)

(f) OBSERVE: (i) immediate **lather (suds, bubbles)** (3)
(ii) **scum / no lather (suds, bubbles)** / **less lather / does not easily form lather** (3)

QUESTION 3

(a) WHAT: **intensity (depth) of colour / absorbance / transmittance** // **proportional to (varies directly with, directly related to, α) concentration** (2 × 4)
Allow (4) for *colour changes with (depends on) concentration.*

(b) IDENTIFY: **acidified potassium iodide (KI/H^+, potassium iodide & ethanoic (sulphuric) acid)** / **DPD**1 tablet / **DPD** reagent and buffer / **N,N-diethyl-*p*-phenylenediamine**

{1-amino-4-diethylamino benzene, $(C_2H_5)_2N$⟨⬡⟩NH_2 } (3)

COLOUR: *for iodide*: **brown/red/orange/yellow** // *for DPD*: **red/pink** (3)
[*Give the marks for one of these colours even if no reagent or an incorrect reagent is given*.]

(c) DESCRIBE: (12)

Comparator		Colorimeter	
Add reagent to sample	(3)	Prepare (obtain, take) standard solutions	(3)
Colour develops	(3)	Place in colorimeter and note readings (absor/transm)	(3)
Compare with chart (disc, card)*	(3)	Plot readings (results/absor/transm) *vs* concentration	(3)
Best match gives concentration	(3)	Get it (concentration) from graph (curve)	(3)

[*The (3) for 'colour develops' can also be given, by inference, from this.]

(d) SPECIES: **chlorine (Cl_2, dichlorine) / chlorate(I) (hypochlorite, ClO^- , OCl^-) / chloric(I) acid (hypochlorous acid, HOCl, HClO) / sodium chlorate(I) (sodium hypochlorite, NaClO, NaOCl) / chlorite {chlorate(III), ClO_2^-} / sodium chlorite {sodium chlorate(III), $NaClO_2$}** (6)

GIVE: need for greater conc. of chlorine in swimming pool water **to kill pathogens (**harmful **bacteria,** harmful **micro-organisms) added by swimmers** / **nitrogenous pollutants in swimming pool** / helps disinfection by **forming chloroamines (combined chlorine) in swimming pool** / **drinking water is less contaminated** / **drinking water has** much **fewer pathogens (**harmful **bacteria,** harmful **micro-organisms) / swimming pool water more contaminated /** higher level **would be dangerous (poisonous) to drink /** higher level **would give a bad taste** to drinking water ['to remove' ≠ 'to kill'] (3)

(e) (i): **650** ppm (9)

$\frac{0.78 \times 1000}{1200} = 0.65 \text{ g l}^{-1}$ (6)

$0.65 \times 1000 = 650$ ppm (3)

(ii): **1280** ppm (6)

$\frac{0.32 \times 1000}{250} = 1.28 \text{ g l}^{-1}$ (3)

$1.28 \times 1000 = 1280$ ppm (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) **$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$ / $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$ / [Ar]$3d^5 4s^1$ / [Ar]$4s^1 3d^5$** (6)
[Allow 3 marks for $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$] [Accept $p_x^2 y^2 z^2$ for $p_x^2 p_y^2 p_z^2$ or p^6 ; accept subscripts]

(b) J J **Thomson** (6)

(c) **involves nucleus** of atoms **not electron cloud (electrons) / involves break-up of nucleus / no breaking (forming) of chemical bonds (or named chemical bonds, or molecules) / chemical involves electrons only** //
involves new elements being generated (made, formed, produced) / transmutation //
involves large scale **release of energy from nucleus** //
involve the release of nuclear radiation (α, β or γ rays) //
mass not conserved in nuclear (2 × 3)

(d) **91.3%** (6)

$\frac{84 \times 100}{92^*}$ (3) = 91.3% (3)

[* *Addition must be shown for error to be treated as a slip but must be based on correct formula*]

(e) (i) **H_3O^+** (3)
(ii) **OH^-** (3)

(f) **identified periodicity of properties / arranged in increasing** rel. **atomic mass (atomic weight)** / in his law of **octaves / repeat every eighth (after seven)** elements (6)

(g) brick-**red** // **precipitate (ppt)** produced (2 × 3)

(h) **11.7** (6)

$M(OH^-) = {}^{0.2}/_{40} = 0.005$ (3)
$M(H^+) = 1 \times 10^{-14} \div 0.005 = 2 \times 10^{-12} \Rightarrow pH = -\log 2 \times 10^{-12} = 11.7$ (3)
OR
$M(OH^-) = {}^{0.2}/_{40} = 0.005$ (3)
$pOH = -\log 0.005 = 2.3 \Rightarrow pH = 14 - 2.3 = 11.7$ (3)

(i) **in solution (in water)** // **in the molten state (in the liquid state)** (2 × 3)

(j) **esters** (6)
[Accept *terpenes*]

(k) **A**: in **flushing (purging)** oil **tanks** // as **inert atmosphere** // in **preserving food** / in **keeping food fresh** / in **packaging food (e.g. crisps)** // **over gas (oil, flammables) in tankers (being transported)** // in **glass production** // in **semiconductor (microchip) production** // **dilutes atmospheric oxygen**
ANY TWO: (2 × 3)

B: *main group*: **aluminium / beryllium / magnesium / calcium** (3)
transition: **titanium / nickel / chromium / zirconium / hafnium** (Allow *zinc or cadmium*) (3)

QUESTION 5

(a) (i) DESCRIBE: **place sample of the salt on a nickel** probe **{platinum (nichrome, steel)** wire**}** //
in (over) a Bunsen **flame** [Accept 'in (over) a Bunsen'] (2 × 4)

(ii) WHY: **each element has a different distribution (set, arrangement) of energy levels / each element has a different electron configuration** (3)

giving rise to **different electron transitions (jumps)** (3)

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

Note: the marks here are not for how spectra are produced; they are for explaining why different elements have different spectra.]

(iii) WHAT: **atomic absorption spectrometry (AAS)** [Accept the spelling *absorbtion*] (3)

(iv) DEFINE: **region** around 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)

(v) WHAT: **it is not possible to measure the** exact **position** //
and energy (momentum, velocity) of an electron in an atom **simultaneously** (2 × 3)

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

(ii) EXPLAIN: **decrease in atomic radius / atoms getting smaller** //
increase in effective **nuclear charge** (2 × 3)

(iii) EXPLAIN: **reactivity increases** //

increase in atomic radius / increase in shells / atoms getting bigger //

effective nuclear charge is the same (effective nuclear charge is +1) / screening (shielding) effect of inner shells cancels the increase in nuclear charge //

outermost electron less tightly held by the nucleus ANY TWO: (6 + 3)

QUESTION 6

(a) (i) WHAT: measure of (indication of, showing, giving) **tendency (likelihood) to auto-ignite (knock, pink, pre-ignite, ignite early, ignite before spark) /** number representing **ability (tendency) of fuel to resist auto-igniting (knocking, pinking, pre-igniting, igniting early, igniting before spark)** (8)

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. (8)

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 (8)

[If (8) not given, allow (4) for mention of '*auto-igniting (knocking, etc….see above)*']

(ii) WHAT: **straight chain** / **unbranched** (3)

(iii) IDENTIFY: *cyclohexane*: **ring / cyclic** (3)
benzene: **aromatic** [Accept *ring / cyclic*] (3)
2,2,4-trimethylpentane: **branched** (3)

(iv) PROCESS: **dehydrocyclisation (cyclodehydrogenation)** (3)

WHY: benzene **is carcinogenic /** benzene **is toxic (poisonous, harmful to health)** (3)

(b) (i) GIVE: **high (increase) octane rating (number) / reduces knocking / fuel burns better / improves fuel efficiency** //

produce clean products / produce clean(er) fuel (petrol) / produce environmentally friendly petrol / reduce pollution / better (more complete) oxidation (oxygenation) / less carbon monoxide produced /do not poison catalyst in **catalytic converter** (2 × 3)

(ii) GIVE: it **poisons (destroys) the** catalyst in **catalytic converter** //
lead emission **presents a health hazard / toxic (poisonous)** to living things (2 × 3)
[Allow for *lead compounds e.g. tetraethyl lead*. Do not accept '*lead is a pollutant*' or '*it damages the environment*']

(c) **– 3924** kJ mol^{-1} (12)

$C + O_2 \longrightarrow CO_2 \quad \Delta H = -394$ kJ mol^{-1} ; $H_2 + \frac{1}{2}O_2 \longrightarrow H_2O \quad \Delta H = -286$ kJ mol^{-1}
$6C + 6H_2 \longrightarrow C_6H_{12} \quad \Delta H = -156$ kJ mol^{-1}

$C_6H_{12} \longrightarrow 6C + 6H_2$	**156** kJ	(3)
$6C + 6O_2 \longrightarrow 6CO_2$	**– 2364** kJ	(3)
$6H_2 + 3O_2 \longrightarrow 6H_2O$	**– 1716** kJ	(3)
$C_6H_6 + 9O_2 \longrightarrow 6CO_2 + 6H_2O$	**– 3924** kJ mol^{-1}	(3)

Equations not required

[**3924** gets (3) only]

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

ΔH = **6 × –394 / –2364** (3) + **6 × –286 / –1716** (3) – {**1 × –156 / –156** (3) + 0}
OR **6 × –394 / –2364** (3) + **6 × –286 / –1716** (3) + **1 × 156 / 156** (3) – 0
=> ΔH_c = **– 3924** (3)

QUESTION 7

(a) DEFINE: minimum **energy** required **for colliding particles (molecules) to react** / minimum **energy** required **for effective collisions** between particles (molecules) (5)
[Accept '*energy needed for colliding particles to initiate reaction*'. Do not accept E_A diagram]
[Allow (3) for '*energy required for reaction to take place*']

(b) GIVE: *first reason*: **increased energy of collisions (particles, molecules, reactants)** (3)
[Accept: *more collisions (particles, molecules, reactants) reach activation energy, more collisions are effective*]

second reason: **increased number of collisions** due to increased velocity (energy) of particles (3)

WHICH: **first reason above** (3)

WHY: for same temperature rise **increase in number of collisions** very **small compared with increase in number reaching activation energy (increase in number being effective)** / **only the high energy collisions lead to reaction (are effective)** / leads to **more (increase in) effective collisions / more collisions reach activation energy / number of collisions reaching (exceeding) activation energy critical for rate** of reaction [Accept '*helps to overcome (exceed) activation energy*'] (3)

(c) DESCR: heat known volumes of **the solutions** separately to a certain temperature (3)

mix, note temperature*, and place reaction vessel **over cross (X, mark),** keeping at temperature (3)
[*Accept a stated temperature]

record time for cross to become invisible and take rate as $^{1}/_{time}$ (3)

repeat for other temperature(s) (3)
[Note: could break in different places and still give all the information required.]

(d) WHEN: $AgNO_3$ and NaCl **present as free ions in solution / no bond breaking (dissociation)** /
For $Na_2S_2O_3$ and HCl covalent **bonds** must be **broken (dissociated)** (6)
[Accept '*$AgNO_3$ and NaCl are ionic*' or '*$Na_2S_2O_3$ and HCl are covalent*' for (3) only]

(e) TYPE: **heterogeneous** catalysis (3)

GIVE: **first entering // first converted to** [The two substances required can both be hydrocarbons or oxides of nitrogen.] (2 x 3)

second entering // second converted to (2 x 3)

entering	converted to
carbon monoxide (CO)	**carbon dioxide (CO_2)**
suitable named hydrocarbon (correct formula) Accept the term '*hydrocarbon*' or *any hydrocarbon*.	**carbon dioxide (CO_2) & water (H_2O)**
named oxide of nitrogen (correct formula) Accept NO_x	**nitrogen (N_2) & oxygen (O_2)** [Accept *nitrogen (N_2)* on its own.

QUESTION 8

(a) (i) WHAT: water which **does not** easily **form lather (forms scum** instead of lather**)** with soap (5)
[Allow (3) for '*water containing calcium or magnesium ions or their salts'*]

(ii) EXPLAIN: **each calcium ion (Ca^{2+})** //
is replaced by 2 sodium ions (Na^+) from the resin (2 × 3)

or

2 RNa + **Ca^{2+}** + $2HCO_3^-$ ⟶ **2 Na^+** + **R_2Ca** + $2HCO_3^-$ (2 x 3)

or

2 RNa + **$Ca(HCO_3)_2$** ⟶ **2 $NaHCO_3$** + **R_2Ca** [Accept $(R)_2Ca$] (2 x 3)

FORMULAS: (3) BALANCING: (3)

(iii) WHAT: **the coming (joining) together (clumping, coagulating)** //
of small (fine) **suspended particles (solids)** in the water (2 × 3)

NAME: **aluminium sulfate / aluminium chloride / aluminium(III) / alum / iron(III) sulfate (ferric sulfate) / iron(III) chloride (ferric chloride) / iron (III) / polyelectrolytes / lime** (3)
[Accept *a correct formula*]

(iv) WHAT: **lime {calcium hydroxide, $Ca(OH)_2$} / sodium hydroxide (caustic soda, NaOH) / sodium carbonate (Na_2CO_3) / soda ash** (3)

WHY: causes **corrosion of pipes** (3)

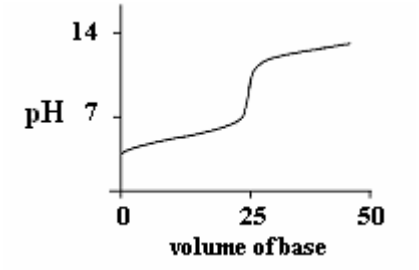
(b) (i) EXPLAIN: the indicator itself dissociates according to the equation

HX ⇌ **H^+** + **X^-** *or* **HX** + **H_2O** ⇌ **H_3O^+** + **X^-** (3)

in acid (low pH) equilibrium lies on the left (shifts backward) giving colour of molecules (HX) / in acid (low pH) indicator is associated (undissociated) giving colour of molecules (HX) Associated = present as molecules (3)

in base (alkali / high pH) equilibrium lies on the right (shifts forward) giving colour of ions (X^-) / in base (alkali / high pH) indicator is dissociated giving colour of ions (X^-) Dissociated = present as ions (ionised) (3)

(ii) DRAW:



graph with pH axis labelled at 7 and number over 7 (3)

neutralisation point at about 25 cm^3 (3)

steep rise at about pH = 6.5 to 10.5 (3)

No labelling or numbers required on horizontal axis.

(iii) EXPLAIN: Phenolphthalein has a pH **range from 8.3 – 10 (8 – 10)** / phenolphthalein **changes colour in steep part of graph** (6)
[Allow (3) for ***weak acid-strong base*** *titration*]

QUESTION 9

(a) WHAT: **general formula / differ by CH_2 / same functional group / similar** chemical **properties / gradation in** physical **properties / similar method of preparation** ANY ONE: (5)

(b) (i) NAME: **aluminium oxide / alumina** (3)
FORMULA: **Al_2O_3** (3)

(ii) IDENTIFY: **glass wool / roc(k)sil** (3)

(iii) WHAT: **remove** the delivery **tube from** the trough of **water** / **disconnect tube (stopper)** from test tube **/ dismantle the apparatus** (3)
WHY: **to prevent suck-back** (3)

(iv) GIVE: manufacture of **polythene (polyethene, plastic) /** make **ethane-1,2-diol (ethylene glycol, antifreeze) /** make **polyester (terylene) /** make **PVC** / make **ethanol / ripening fruit /** make **poly(phenylethene) {polystyrene}** (3)
[*Do not allow general terms e.g. "medicine", "agriculture", "industry", "engineering", but do not cancel them with an acceptable use.*]

(c) DESCRIBE: **polarisation of Br_2 / heterolytic fission of the bromine molecule / $Br_2 \rightarrow Br^+ + Br^-$ //**

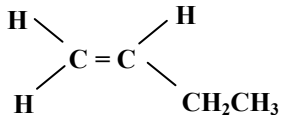
addition of bromonium ion (Br^+) across the double bond / addition of Br^+ forming bridged intermediate (cyclic bromonium ion) // [Accept *localised carbonium ion*]

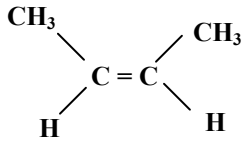
attack (addition) of bromide ion (Br^-) to the bridged intermediate {cyclic bromonium ion, carbonium ion (C^+) } *[Bromide ion (Br^-) must be shown or mentioned.]* (3 × 3)
[*Marks may be got from information given on suitable diagrams.*]

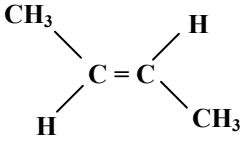
STATE: **other products are formed when the reaction is carried out in the presence of other nucleophiles (anions, negative ions) {e.g. Cl^- (NaCl, HCl) / OH^- (H_2O)}** [*May be got from a specific example e.g.2-bromoethanol formed using bromine water (Br_2/H_2O*] (3)

EXPLAIN: **these products indicate a positive* (carbonium ion) intermediate / these products support a mechanism with a positive (carbonium ion) intermediate**** (3)
[Accept for 3 marks only: '*reaction works in the dark at room temp. showing that free radicals are not involved.*]
[* For positive, accept also 'ionic', 'Br^+'] [**Accept 'intermediate' said in other ways.]

(d) DRAW:



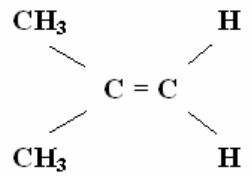
//


//


//

CH_2=CHCH$_2$CH$_3$
but-1-ene (1-butene)

CH$_3$CH=CHCH$_3$
but-2-ene (2-butene)



TWO FORMULAS WITH MATCHING NAMES / TWO NAMES WITH MATCHING FORMULAS [Note: *cis- or trans- or E- or Z- not required*] (4 x 3)

(CH$_3$)$_2$C=CH$_2$
2-methylpropene

[In expanded structures, bonds without Hs are acceptable. Number not reqd. for 2-methylpropene (allow -1-ene) but award no marks if the number is incorrect. Apply cancelling if more than two structures are given. Maximum loss is – 3]

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

(a) (i) WHAT: atoms of **same element (same atomic number, same number of protons)** having **different mass** numbers **(different numbers of neutrons)** (4)

(ii) DEFINE: **average mass of atom(s)** of element / **average of isotopes taking abundances into account** // **relative to (based on)** $^1/_{12}$ mass of **carbon-12** atom (2 × 3)

(iii) WHAT: positive **ions (particles) separated (deflected, spread out)** // **based on (according to)** relative **mass(es) {charge/mass ratio}** // when moving **in a magnetic field** (3 × 3)

(iv) CALC.: **6.926** [Accept 6.93 for (6); give (3) for 6.9 if there is nothing else worth marks.] (6)

7.4 x 6 + 92.6 x 7 = 692.6 (3) ÷ 100 = 6.926 (3)

(b) DEFINE: **increase** (4)

WHAT: (i) **+1** [Accept 1] (3)
(ii) **+5** [Accept 5] (3)

STATE: **+2** [Accept 2] (3)

EXPLAIN: oxygen is **more electropositive** / **less electronegative** / **fluorine is more electronegative / fluorine is less electropositive** [*Allow even if ox. no. incorrect.*] (3)

IDENTIFY: **potassium iodide (KI) solution / potassium iodide (KI) / iodide (I^-) / I(–1** to 0**)** (3)

COLOURS: **purple / violet / maroon** (3)
to brown / red / orange/ yellow (3)

(c) (i) GIVE: alcohols have **higher (bigger)** relative **molecular mass** // and polar **hydroxyl group (polar OH) /** intermolecular **hydrogen bonds** (4 + 3)

(ii) EXPLAIN: **effect (contrib.) of OH less in butanol / hydrogen bonding weaker in butanol / due to longer carbon chain** / **due to bigger non-polar part** of molecule (6)

OR

effect (contrib.) of OH greater in methanol / hydrogen bonding stronger in methanol / due to shorter carbon chain / due to smaller non-polar part of molecule (6)

[In absence of above 6, allow 3 marks for '*M_r of CH_3OH is double M_r of CH_4 but M_r of C_4H_9OH is only slightly bigger than M_r of C_4H_{10}*']

(iii) DESCRIBE: *methane*: virtually **insoluble** //
methanol: completely **soluble (miscible) / miscible in all proportions** //
butane: virtually **insoluble** //
butanol: **slightly (sparingly) soluble / less soluble than methanol** (4 x 3)

['*All alkanes insoluble*' gets (6); '*All alcohols soluble*' gets (3); *stating the relative solubilities of the four compounds* can get (9); *stating the relative solubilities of the four compounds and giving the solubility of one of them* can get (12)]

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

(a) (i) WHAT: perfectly **obeys the gas laws (Boyle's law, kinetic theory, *PV = nRT*)** under all conditions of temperature and pressure (4)

(ii) GIVE: **intermolecular forces (attractions between molecules, named correct inter-molecular force) / molecules have volume (molecules take up space, volume of molecules not negligible) / collisions not** perfectly **elastic** ANY ONE: (3)

(iii) MOLES: **0.03** mol (9)

PV = nRT $1 \times 10^5 \times \mathbf{720 \times 10^{-6}} = n \times 8.3 \times \mathbf{283}$ (2 x 3) $n = \mathbf{0.03}$ (3)	$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$ $\frac{1 \times 10^5 \times 720}{\mathbf{283}} = \frac{1 \times 10^5 \text{ (or } 1.013 \times 10^5\text{)} \times V_2}{273}$ $V_2 =$ 685 to 695 (2 x 3) $\div$ **22400** = **0.03** (3)

[Marks in context of correct operations. *Not given correct to one significant figure* (–1)]

(iv) MOLECULES: **1.8×10^{22}** $0.03 \times 6 \times 10^{23} = 1.8 \times 10^{22}$ (3) (3)

(v) MASS: **2.22** g (6)

0.03 mol $CO_2 \equiv$ 0.03 mol $Ca(OH)_2$ (3)** $0.03 \times 74^* = 2.22$ (3)
[* *Addition must be shown for error to be treated as a slip.*]

** *Can be given for 1 : 1 ratio or for 0.03 mol $Ca(OH)_2$*

(b) STATE: reactions **at equilibrium** // **oppose (minimise, relieve) applied stress(es)*** (4 + 3)
[**If the word stress(es) is replaced by particular examples (e.g. pressure), all three (temperature, pressure & concentration) must be given.*]

(i) WHEN: **no** (3)

EXPLAIN: **forward and reverse reactions continue** at same rate **/ reactants changing to products and products changing to reactants** (3)

(ii) STATE: **becomes pink** (3)

EXPLAIN: equilibrium **shifts (moves, goes) to left / shifts backwards / shifts in reverse / shifts in the exothermic direction / shifts to produce heat / shifts to oppose (minimise) cooling / shifts to minimise (oppose) stress** (3)

(iii) HOW: **add** conc. **hydrochloric acid (HCl) / add chloride ions (Cl^-) / add** source of **chloride ions (Cl^-) e.g NaCl / remove water** (6)

Question 11 continued/

(c) **A**

AMMONIA:

(i) WHAT: **air // natural gas (methane, CH_4) // water** ANY TWO: (2 x 3)

DESCRIBE: *air*: **filter / liquefaction (distillation) / natural gas (methane, CH_4) burned in it** to get nitrogen //
natural gas: **desulfurise / steam reform (react with steam)** //
water: **deionised / react with natural gas (steam reforming)**
TWO MATCHING THE STATED RAW MATERIALS: (2 x 3)

(ii) NAME: **ammonia / carbon dioxide / oxides of nitrogen (correctly named)** (3)
[Accept *formulas*]

(iii) STATE: **fertilisers {urea, $CO(NH_2)_2$, C.A.N., any sol. amm. salt} / nylon / nitric acid (HNO_3)** (6)
WHAT: contains **nitrogen** (4)

or

NITRIC ACID:

(i) WHAT: **ammonia / air / water** ANY TWO: (2 x 3)

DESCRIBE: *ammonia*: **no treatment / filter (remove dust) / vaporise //**
air: **filter (remove dust) //**
water: **deionise** TWO MATCHING THE STATED RAW MATERIALS: (2 x 3)

(ii) NAME: **nitric acid / nitrates / oxides of nitrogen (correctly named)** (3)
[Accept *formulas*]

(iii) STATE: **fertilisers (ammonium nitrate, NH_4NO_3, any soluble nitrate) / nylon / explosives** (6)
WHAT: *fertilisers & nylon*: contains **nitrogen** // *explosives*: **unstable compounds** / **oxygen rich** (4)

or

MAGNESIUM OXIDE:

(i) WHAT: **limestone / sea water / fresh (river) water** ANY TWO: (2 x 3)

DESCRIBE: *limestone*: **crushed / washed / calcined {burnt (heated) to quicklime (calcium oxide, CaO)} / slaked [water added to form slaked lime {calcium hydroxide, $Ca(OH)_2$}]** //
sea water: **acidified (H_2SO_4 added, pH lowered) / degassed (CO_2 removed) / clarified (solids settle)** //
fresh water: **acidified (H_2SO_4 added, pH lowered) / degassed (CO_2 removed)**
TWO MATCHING THE STATED RAW MATERIALS: (2 x 3)

(ii) NAME: **dust, suspended solids, lime (calcium hydroxide), magnesium oxide, oxides of sulphur (named correctly)** (3)
[Accept *formulas*]

(iii) STATE: **refractory (heat-resistant) materials (ceramics)** / **furnace linings (walls)** (6)
WHAT: very **high melting point / melting point > 2000 ^oC** / **insulating** (4)

(c) **B**

(i) WHAT: **iron ore {haematite (Fe_2O_3), magnetite (Fe_3O_4), siderite ($FeCO_3$), pyrite (iron pyrites, FeS_2)}** //
coke (C) //
limestone (calcium carbonate/$CaCO_3$) //
hot **air** (4 x 3)

(ii) NAME: **carbon monoxide (CO)** (3)
EQUATION: **$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$** FORMULAS: (3) BALANCING: (3)

(iii) WHY: pig iron **brittle (impure, high carbon content) / great(er) demand for steel / small(er) demand for pig iron / steel more useful / pig iron less useful / pig iron cannot be re-worked / pig iron rusts** more **easily** (4)