Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE 2011

MARKING SCHEME

CHEMISTRY

HIGHER LEVEL

Introduction

In considering the marking scheme the following should be noted.

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

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

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

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

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

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

Outline Marking Scheme

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

Section A

Question 1

(a) Describe: 4 × 3; (b) Colour: 3, Excess: 2 × 3; (c) Tile: 3; (d) Indicator: 3, Change: 3;
(e) Calculate: *(i)* 9, *(ii)* 3; (f) Original: *(i)* 3, *(ii)* 5.

Question 2

(a) Identify: 6, Draw: 4 × 3, What: 6, How: 6; (b) *(i)* What: 5, *(ii)* App: 6,
(iii) Sub: 3, *(iv)* Iden: 3, 3.

Question 3

(a) Stage 1: 5; (b) *(i)* 3, *(ii)* 3; (c) Stage 3: 6; (d) Compare: 2 × 3; (e) Drying: 3;
(f) Describe: 4 × 3, Differ: 2 × 3; (g) Use: 6.

Section B

Question 4

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

(a) Give: 2 × 3; (b) State: 2 × 3; (c) Shapes: 2 × 3; (d) Define: 6; (e) Calc: 6; (f) Equat: 2 × 3;
(g) Give: 2 × 3; (h) Define: 2 × 3; (i) What: 2 × 3; (j) Princ: 2 × 3; (k) **A**: 2 × 3, **B**: 2 × 3.

Question 5

(a) Define:*(i)* 5, *(ii)* 2 × 3; (b) Basis: 2 × 3, Spaces: 3, Rever: 3; (c) Expl: *(i)* 6; *(ii)* 3;
(d) *(i)* Define: 2 × 3, *(ii)* Write: 6, *(iii)* What: 6.

Question 6

(a) Nat: 5; (b) Desc: 4 × 3, Use: 3; (c) What: 2 × 3, Why: 3; (d) *(i)* 6, *(ii)* 3; (e) Calc: 12.

Question 7

(a) *(i)* 2 × 3, *(ii)* 2 × 3; (b) *(i)* 3; *(ii)* 3; Which: 3; Expl: 3; (c) Expl: 6

(d) Def: 6, Calc: 9, Conc: 5.

Question 8

(a) Desc: 4 × 3, State: 3 × (2 × 3); (b) *(i)* Name: 3, *(ii)* Broken, Formed: 6 + 3; (c) Desc: 3 + 3 + 2.

Question 9

(a) Write: 5, Calc: 18; (b) Expl: *(i)* 2 × 3, *(ii)* 2 × 3, *(iii)* 2 × 3; Is: 3, Justify: 6.

Question 10

(a) Define: 5, Suggest: 6, Describe: 6, Draw: 3, 5.

(b) Write: 4, 3, Name: 3, Calc: 9, 6.

(c) What: 3 + 2, Define: *(i)* 3 + 2, *(ii)* 3, Write: 2 × 3, Expl: 6.

Question 11

(a) BOD: 4 + 3, *(i)* Desc: 6 + 3, *(ii)* Expl: 6 + 3.

(b) *(i)* Dist: 4 + 3, *(ii)* Why: 2 × 3,*(iii)* Show: 2 × 3, Desc: 2 × 3.

(c) **A** *(i)* Iden: 4, *(ii)* What: 3, *(iii)* Draw: 6, *(iv)* Give: 4 × 3.
B Outline: 4 + 3, Why: 3, *(i)* 3, *(ii)* 3, *(iii)* 3, *(iv)* Name: 3, Give: 3.

SECTION A

QUESTION 1

(a) DESCRIBE: pipette into 500 cm^3 **volumetric flask** // [*Obtainable from diagram.*]
add **deionised (distilled, pure) water** until near mark //
add dropwise (by dropper, by wash bottle, other suitable method) //
until **bottom of meniscus up to (on, at) mark** / flask **at eye-level (vertical)** //
stopper and **invert** several times / **mix** thoroughly / solution **homogeneous (even concentration, same concentration throughout)** ANY FOUR: (4 × 3)

(b) COLOUR: **brown / red / reddish-brown /** dark **orange** (3)

EXCESS: so that **all the bleach (hypochlorite) has reacted (max of iodine produced)** //
to **keep** the **iodine in solution** (2 × 3)

(c) TILE: so that **colour**-change **(end-point) clear**er **(**more **easily seen)** (3)

(d) INDICATOR: **starch** (3)

CHANGE: **blue (or blue-black) to colourless** [*Do not accept 'clear' for 'colourless.'*] (3)

(e) CALCULATE: (i) **0.0322 / 0.032** M (9)

$$\frac{(25 \times X)}{1} = \frac{(16.1 \times 0.1)}{2} \quad (6)$$

$$X = 0.0322 / 0.032 \quad (3)$$

(ii) **0.644 / 0.64** M (3)

$$0.0322 / 0.032 \times 20 = 0.644 / 0.64 \quad (3)$$

(f) ORIGINAL: (i) **47.6 – 48.0** g l^{-1} (3)

$$0.644 / 0.64 \times 74.5^* = 47.978 / 47.98 / 48 / 47.68 / 47.7 \quad (5)$$
**Addition must be shown for error to be treated as a slip*

[*Use of A_r values from table is acceptable*]

(ii) **4.76 – 4.80** % (w/v) (5)

$$47.978 \div 10 = 4.7978 / 4.798 / 4.8 / 4.768 / 4.77 \quad (3)$$

QUESTION 2

(a) IDENTIFY: **preparation of soap / preparation of ethanoic (acetic) acid (CH_3COOH) / preparation of carboxylic acid / ethanol to ethanoic (acetic) acid** (6)

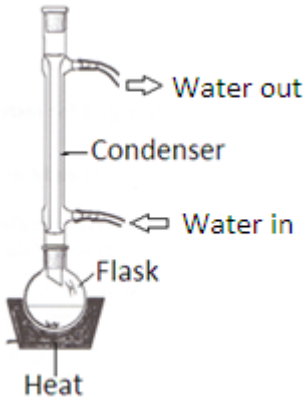
DRAW: **flask with contents shown or labelled //**

anti-bumping granules //

condenser in correct position //

correct flow of water clearly indicated //

labelled or identifiable source of heat



[*Allow water bath, mantle, Bunsen unlabelled*]

[*Fewer than <u>three</u> labels: – 3*] ANY FOUR: (4 × 3)

[*Marks awarded in context of valid apparatus*]

WHAT: hot **vapour rose** / liquid **evaporated (entered condenser) /**

vapour was **condensed (changed to liquid)** / **returned to flask** (6)

HOW: allowed enough **time (or concept of time)** to bring reaction to completion /

provide the activation **energy /**

heating **without loss of reactants (vapour) / by keeping the reactants together / in open apparatus (vessel, container)** ANY ONE: (6)

[*Answers to WHAT and HOW may be mixed*]

(b) (i) WHAT: **clove oil (eugenol) / rose oil / oil of lavender / oil of thyme / oil of fennel / citrus (orange, lemon, lime, grapefruit) oil / other correct natural product** (5)

(ii) APP: **cloudy / milky / creamy / emulsion** [*Accept white (whitish); not 'clear.'*] (6)

(iii) SUB: **water (H_2O, steam)** (3)

(iv) IDEN: **feature** (3)

explanation (3)

FEATURE	EXPLANATION
Safety tube / steam tube	**Releases pressure / releases steam / preventing explosion**
Air-tight seals	**No steam escapes / preventing burns (scalds)**

[*Feature and explanation must be matched*]

QUESTION 3

(a) STAGE 1: crystals in **minimum of** hot **water (solvent) / maximum of crystals in** hot **water (solvent) /** hot almost **saturated solution** of crystals (5)

(b) (i) **charcoal / C / insoluble** solid (3)

(ii) pure (purified, recrystallized) **benzoic acid** (3)

(c) STAGE 3: further **cooling (place flask in ice-water) / evaporate** some **more water** (6)
[*Accept 'hold under tap'*]

(d) COMPARE: **both** substances **soluble in hot water //**

benzoic acid much **less soluble (insoluble) in cold water** so comes (crystallises) out of solution / **NaCl** much more **soluble in cold water** so remains in solution (2 × 3)

(e) DRYING: **warm place /** put in **desiccator (dehydrator) /** dry in warm **oven** / leave on **drying tray / air dry (e.g. leave on a radiator, leave aside, leave on filter paper)** (3)

(f) DESCRIBE: **sample in melting point tube / sample on** melting **block //**

mp tube attached (strapped) to thermometer / mp tube in mp apparatus with thermometer / thermometer in melting **block //**

heated in liquid paraffin* / heat block / heat in mp apparatus //

note temperature range over which (or **temp at which) it melts / observe melting point** (4 × 3)

**Or other suitable liquid (not water)*

[*Absence of diagram with at least one label: deduct 3 marks.*]

DIFFER: **impure lower (recrystallized higher) / impure farther from correct value (value in tables) {recrystallized closer to correct value (value in tables)} //**

impure less (not) sharp (has wide/wider range) {recrystallised sharper **(**has **narrow**er **range)}** (2 × 3)

(g) USE: food **preservative / disinfectant (antiseptic, fungicide) / calibration** (6)

SECTION B

QUESTION 4

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

(a) GIVE: **negatively** charged **(attracted to anode)** // **negligible mass // straight-line motion // penetrating // cause fluorescence // move paddle wheel // deflected by electric field // deflected by magnetic field // high-speed** ANY TWO: (2 × 3)

(b) STATE: **equal (same) volumes of gases contain equal (same) numbers of molecules (particles, moles) //**
under same (*not 'all'*) **conditions (temp. and pressure)** (*not 'at s.t.p.'*) (2 × 3)
[*Allow (3) for 'molar volume at s.t.p. = 22.4 litres.'*]

(c) SHAPES: **linear / straight // bent / angular / V-shaped** [*Accept correct diagrams*] (2 × 3)

(d) DEFINE: amount containing **as many particles* as** the number of atoms in **0.012 kg (12 g) of carbon-12 /** amount equal to the relative **formula (molecular) mass** expressed **in grams /** amount containing the **Avogadro number (Avogadro constant, *L*, 6 × 10^{23})** of **particles*** (6)
[**Accept 'atoms', 'molecules', 'ions', 'units' for 'particles'*]

(e) CALC: $x = 7$ (6)

$\frac{2.00}{2.10} = \frac{120}{18x} / \frac{2}{120} : \frac{2.1}{18}$: $MgSO_4.xH_2O$ = 246 / water = 126 (3) => $x = 7$ (3)

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

(f) EQUAT: **$3Cu^{2+}$ + 2Al → 3Cu + $2Al^{3+}$** FORMULAS // BALANCING: (2 × 3)

(g) GIVE: **distillation // ion exchange** resin **(deioniser) // zeolites // washing soda (bath salts)** ANY TWO: (2 × 3)

(h) DEFINE: minimum **energy of / energy required for //**
particles colliding to react / to initiate reaction / for effective collision to occur [*Do not accept 'for reaction to occur.'*] (2 × 3)

(i) WHAT: **general formula // differ by CH_2 // same functional group // similar chemical properties // gradation in physical properties // similar method of preparation**
Accept **'uniform chemical type'** for **'sim. chem. properties.'** ANY TWO: (2 × 3)

(j) PRINC: **based on their** selective **adsorbance on / based on their** relative **affinities (attractions) for / based on their partitioning between / based on their** different **interactions with //**
a stationary phase and a mobile phase (2 × 3)

(k) **A** **outer (delocalised) // electrons free to move** (2 ×3)
or
B **greenhouse effect relative // to carbon dioxide**, which is given a value of 1 (2 ×3)

QUESTION 5

(a) DEFINE: (i) **number of protons** in the nucleus of an atom of the element (5)
[*Do not accept 'number of electrons.'*]

(ii) **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)

(b) BASIS: when arranged **according to (in order of)** increasing **atomic weight (**relative **atomic mass) //**
there is a **periodic occurrence (repeat) of similar elements (**elements with similar **properties) / similar elements (**elements with similar **properties) recur at intervals /** arranged elements **grouped by similar properties** (2 × 3)

SPACES: so that **similar elements (elements with same properties)** were **in same group /**
because **next element wouldn't fit /** because of **undiscovered elements /**
because **next** known **element (e.g. As) unlike next group (B group, Grp. III) /**
because **next** known **element (e.g. As)** more **like group further on (N group, Group V)** (3)

REVER: to **suit (fit) properties to groups /**
the **lower atomic mass element fitted better in the higher group** and *vice versa* **/**
tellurium fitted better with (has properties like) the O group (Grp. VI) / **iodine fitted better with (has properties like) the halogens (F group, Group VII)** (3)

(c) EXPL: (i) **readily lose single (an) electron** in outer shell **/ low** first **ionisation energy** (6)
[*Allow 3 marks for: due to 'small effective nuclear charge (high shielding effect by inner shells)'/ 'to give stable octet (noble gas configuration)'*]

(ii) **increase in atomic radius / atoms getting bigger / outer electron** getting **further from nucleus / decrease in** first **ionisation energy / outer electron more easily lost** (3)

(d) (i) DEFINE: **region (space,** *accept 'area'***)** around the nucleus of an atom //
where there is a 99 % (high) probability of finding an electron /
where electron most **likely to be found** (2 × 3)

or

space occupied by electron //
described by solution of Schrödinger equation (2 × 3)

(ii) WRITE: **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$ / [Ar]$4s^2 3d^5$ / $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$ / [Ar]$3d^5 4s^2$** (6)
[*Accept $p_x^2 p_y^2 p_z^2$ for $p_x^2 p_y^2 p_z^2$ or p^6; accept subscripts.*]

(iii) WHAT: **electrons entering (occupying) 3d** sublevel (**All end in $3d_x$)** (6)
[*Accept 'their outer electrons in 3d,' 'their outer sublevel is 3d,' all have electrons in 3d.' Do not accept 'partially filled 3d.' Accept 'partially or completely filled 3d'*]

QUESTION 6

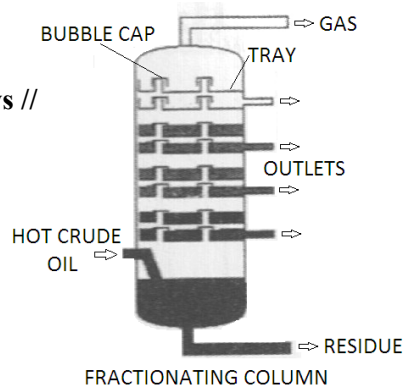
(a) NAT: **hydrocarbons (cpds of C and H)** [*Accept 'alkanes (paraffins)'*] (5)

(b) DESC: **hot crude oil introduced at base of** fractionating **column / heated at bottom** of column / **heated below trays //**

vapour **moves up through a series of trays (levels) //**

fractions come off through outlets /
fractions come off at these **levels (trays) //**

depending on their boiling points /
higher bp (heavier) fractions come of at lower levels /
lower bp (lighter) fractions come off at higher levels /
temperature gradient shown / highest **T at bottom (low**est **T at top)** (4 × 3)



[*In the absence of a diagram with at least two labels deduct (3) marks.*]

USE: **petrol / motor fuel** (3)

(c) WHAT: **splitting (breaking) of long chain molecules (hydrocarbons) //**
by the action of **heat** and catalyst(s) / **to give short chains (small molecules)** (2 × 3)

WHY: **gives useful products (more demand for products) / products needed for petrol /** products used as feedstock **for chemical industry (source of alkenes, source of ethene) / gives** products with **higher octane numbers** (3)

(d) (i) **electrolysis** (6)

(ii) **difficult to store / difficult to transport / not easily liquefied / tanks** have **to withstand high pressures / low density (light) / explosive** (3)

(e) CALC: ΔH = **205.6** kJ mol^{-1} (12)

CH_4		→	C	+ $2H_2$	ΔH =	**74.6** kJ	(3)
C +	$\frac{1}{2}O_2$	→	CO		ΔH =	**–111** kJ	(3)
H_2O		→	H_2	+ $\frac{1}{2}O_2$	ΔH =	**242** kJ	(3)
CH_4 +	H_2O	→	CO	+ $3H_2$	ΔH =	**205.6** kJ	(3)

Equations not required

$\Delta H_{(reaction)}$ = $\Sigma\Delta H_{f(products)}$ – $\Sigma\Delta H_{f(reactants)}$
= **– 111** (3) – {**– 74.6** (3) **– 242** (3)}
or = **– 111** (3) + **74.6** (3) + **242** (3)
= **205.6** kJ (3)

QUESTION 7

(a) (i) *strong*: almost **completely dissociated to give hydrogen ions (H^+)** in solution //
[*Accept 'readily,' 'fully' for 'completely'.*]

weak: only **slightly dissociated to give hydrogen ions (H^+)** in solution (2 × 3)
[*Accept 'partially' for 'slightly.' Do not accept 'not fully' for 'slightly.'*]

(ii) *strong*: **good proton (hydrogen ion, H^+) donor //**
weak: **poor proton (hydrogen ion, H^+) donor** (2 × 3)

(b) (i) *sulfuric acid*: **HSO_4^-** (3)

(ii) *HA*: **A^-** (3)

WHICH: **A^- / conjugate** base **of weak acid** (3)

EXPL: **conjugate** base **of weak acid / weak acids (HA) exist(s) in undissociated (associated, unionised, molecular) form** in water / **A^- more likely to accept a proton / strong acids (H_2SO_4) remain dissociated (ionised)** in water (3)

(c) EXPL: **$HSO_4^- + H_2O \rightarrow SO_4^{2-} + H_3O^+$** (6)
[*If incomplete, mark as:* $HSO_4^- \rightarrow SO_4^{2-}$ // $H_2O \rightarrow H_3O^+$ (2 × 3)]

(d) DEF: **minus log (negative log)** to base 10 **of hydrogen (hydronium) ion concentration /**

$$-\log_{10}[H^+] \;/\; -\log_{10}[H_3O^+] \;/\; \log_{10}\frac{1}{[H^+]} \;/\; \log_{10}\frac{1}{[H_3O^+]}$$ (6)

CALC: pH = **2.45** (9)

$K_a = \frac{[H^+][A^-]}{[HA]} / \frac{[H^+]^2}{0.2} = 6.3 \times 10^{-5} / [H^+]^2 = 1.26 \times 10^{-5}$ (3)

$\Rightarrow$ $[H^+] = 3.5 \times 10^{-3}$ (3)

$\Rightarrow$ pH = **2.45** (3)

or

pH = $-\log_{10}\sqrt{K_a[M]}$
= $-\log_{10}\sqrt{[6.3 \times 10^{-5}].[0.2]}$
pH = 2.45

$[H^+] = \sqrt{K_a[M]}$
= $\sqrt{[6.3 \times 10^{-5}].[0.2]}$
pH = 2.45

CONC: **$1.75 \times 10^{-3} - 1.77 \times 10^{-3}$** (5)

$[H^+]$ / inv. log – pH / inv. log – 2.45 = 3.55×10^{-3} / 3.5×10^{-3} (3)

$\Rightarrow$ M = $3.55 \times 10^{-3} \div 2$ = **1.77×10^{-3} / 1.75×10^{-3}** (2)

QUESTION 8

(a) DESC: *initiation*: **homolysis (splitting) of chlorine molecule (Cl_2) into free radicals ($Cl^{\bullet}$) by ultraviolet (uv)** light / $Cl_2 \xrightarrow{uv} 2Cl^{\bullet}$ //

propagation: **reaction of chlorine radical ($Cl^{\bullet}$) with methane molecule (CH_4) to give hydrogen chloride (HCl) and a methyl radical ($CH_3^{\bullet}$) /**
$Cl^{\bullet} + CH_4 \rightarrow HCl + CH_3^{\bullet}$ //
reaction of methyl radical ($CH_3^{\bullet}$) with a chlorine molecule (Cl_2) to give mono**chloromethane (CH_3Cl) and a chlorine radical ($Cl^{\bullet}$) /**
$CH_3^{\bullet} + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$ //

chain reaction occurs //

termination: **combination of** remaining **radicals to form molecules /**
$Cl^{\bullet} + CH_3^{\bullet} \rightarrow CH_3Cl$ /
$2Cl^{\bullet} \rightarrow Cl_2$ /
$CH_3^{\bullet} + CH_3^{\bullet} \rightarrow C_2H_6$ ANY FOUR: (4 × 3)

STATE: **three × [piece of evidence // corresponding explanation]** 3 × (2 × 3)

PIECE OF EVIDENCE	**CORRESPONDING EXPLANATION***
promoted **by uv** at room temp	**effect of uv suggests free radical mech. / photons (uv, hυ) split Cl_2 / energy unable to split C – H /** accept **does not take place in the dark** at room temp.
for every photon absorbed many chloromethane molecules formed	**evidence for chain reaction or propagation**
ethane formed	**shows $CH_3^{\bullet}$ present /** $2CH_3^{\bullet} \rightarrow C_2H_6$ [*not given from termination above*]
add source of free radicals {tetra-methyl (tetraethyl) lead}	**only free radical mech. would be affected / increased rate / ionic addition unaffected / free radicals promote chain reaction**
inhibitors (e.g. oxygen) slow reaction	inhibition **sure indicator of chain reaction / inhibitor (O_2) combines with radicals ($CH_3^{\bullet}$) / inhibitor (O_2) stops chain** formation
no H_2 produced	**no $H^{\bullet}$ formed / C – H not split** by uv
HCl produced	**shows $Cl^{\bullet}$ produced / proves $Cl^{\bullet}$ attacks CH_4**

Piece of evidence and explanation must be matched

(b) (i) NAME: **elimination** [*Accept 'dehydration.'*] (3)

(ii) BROKEN: **C – H and C – O**
FORMED: **C = C and O – H / C to C π (pi) bond and O – H** (6 + 3)

(c) DESCRIBE: six identical **carbon-to-carbon sigma (single) bonds //**
sigma (single) bonds from carbon to hydrogen //
delocalised π (pi) electron(s) (bonds, cloud) / formed from six p orbitals (electrons) [*Accept correct description*] (3 + 3 + 2)
or
identical carbon-to-carbon bonds //
intermediate in length **between single and double** / **resonance str (hybrid) //**
delocalised π (pi) electron(s) (bonds, cloud) / formed from six p orbitals (electrons) / six delocalised electrons (3 + 3 + 2)

QUESTION 9

(a) WRITE: $\frac{[H_2][I_2]}{[HI]^2}$ (5)

CALC: **0.044 – 0.045** mol l^{-1} (18)

Let x = number of moles of hydrogen at equilibrium

	2HI	⇌	**H_2**	+	**I_2**	
Start:	5 mol		0 mol		0 mol	
Equil:	**(5 – 2*x*)** mol		***x*** mol		***x*** mol	(3)

$\frac{x^2}{[5-2x]^2}$ = **0.0185** (6)

x = **0.53 – 0.54** mol (6)

Conc: 0.53 ÷ 12 = **0.044 – 0.045** mol l^{-1} (3)

Let x = molar conc. of hydrogen at equilibrium
Volume of container = 12 litres

	2HI	⇌	**H_2**	+	**I_2**	
Start:	5 mol		0 mol		0 mol	
Conc:	**0.42** M		**0** M		**0** M	(3)
Equil:	**(0.42 – 2*x*)** M		***x*** M		***x*** M	(3)

$\frac{x^2}{[0.42-2x]^2}$ = **0.0185** (6)

x = **0.044 – 0.045** mol l^{-1} (6)

(b) EXPL: (i) **evidence of an equilibrium //**
approx **equal (similar) amounts of both species //**
shifted forward (to the right) / shifted to decrease Cl^- concentration //
according to Le Châtelier's principle ANY TWO: (2 × 3)

(ii) **pink //**

shifted backward (to the left) / shifted to decrease H_2O concentration (2 × 3)

(iii) **blue //**

shifted forward (to the right) / shifted to decrease Cl^- concentration (2 × 3)

IS: **endothermic** (3)

JUSTIFY: **cooling** always **shifts in the exothermic (heat producing) direction /**
backward (left) shift is exothermic for this reaction (6)

QUESTION 10

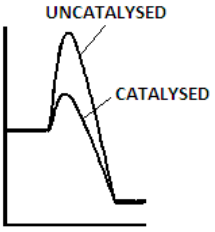
(a) DEFINE: **change in concentration per unit time / rate of change of concentration /** $\frac{\textbf{change in concentration}}{\textbf{time}}$ (5)

SUGGEST: **heterogeneous** (not 'hetero') **/ surface / adsorption** (6)

DESCRIBE: **reactants adsorbed** on surface of catalyst / forming **activated complex / lowering activation energy / higher concentration** on surface / **occupying active sites** on surface / **chemisorbed (chemically attached) / bond stretching (loosening, weakening, breaking) / oriented correctly** for reaction / **desorption** (6)
[*Diagrams may contain the required information.*]

DRAW: **reactants line higher than products line //** (3)

catalysed and uncatalysed curves correctly shown with either one correctly labelled (5)



(b) WRITE: $\mathbf{C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2}$ FORMULAS // BALANCING: (4, 3)

NAME: **ethanal (acetaldehyde)** (3)

CALC: **6.6** hours (9)

12.5 % of 350 ml	=	**43.75 ml ethanol**	(3)
43.75 × 0.8	=	**35 g**	(3)
35 ÷ 5.3	=	**6.6** hours	(3)

112.5 mg/100 ml blood (6)

90 % of 35 g	=	**31.5 g ethanol**	(3)
31.5 g in 28 l	=	**112.5** mg/100 ml	(3)

[*Penalty of 3 marks if calculated using man's rate*]

(c) WHAT: atoms of **same element (same atomic number, same number of protons) //** having **different mass** numbers (**different numbers of neutrons**) (3 + 2)

DEFINE: (i) **spontaneous** random **decay of (disintegration of, decomposition of, breaking up of, change within) a nucleus // to release** α, β or γ **radiation** (3 + 2)

or

spontaneous random **emission of radiation (radiant energy, rays, particles) // from unstable nuclei / due to decay of** (*see alternatives above*) **a nucleus** (3 + 2)

(ii) **radioactive isotope** / **radioactive form of element /** forms of **elements that emit radiation / isotope with unstable nucleus** (3)

WRITE: $\mathbf{^{14}_{6}C \rightarrow {}^{0}_{-1}e + {}^{14}_{7}N}$ (2 × 3)
[*Accept* β *for* e]

EXPL: **carbon–14 decayed (changed to nitrogen)** (6)

QUESTION 11

(a) BOD: p.p.m. (mg l^{-1}) of **oxygen consumed //**
when sample **kept in the dark for five days at 20 ^{o}C (293 K)** (4 + 3)

(i) DESC: **removal of solids (debris, particles, etc.) //**
by screening //
and settlement (sedimentation, grit channels) (6 + 3)

(ii) EXPL: **digestion (breakdown, decomposition, oxidation*) //**
aerobically (**mixed with air, aeration**) / **anaerobic**ally / by **oxidation* //**
involving **micro-organisms (bacteria) / activated sludge / biological** (6 + 3)

**Marks can only be given once for 'oxidation.'*

(b) (i) DIST: *ionic*: bond (force of attraction) **between oppositely-charged ions /**
bond **involving transfer (loss <u>and</u> gain) of electrons //**

polar: **unequal sharing of** bonding **electrons {electron pair(s)} /**
bond has **slight positive (δ^+) and slight negative (δ^-)** ends (4 + 3)

(ii) WHY: *molten/dissolved*: **ions free to move //**
solid: **ions not free to move / ions locked (fixed)** in position (2 × 3)

(iii) SHOW: there is an **electronegativity difference (values acceptable)** between N and H //
showing **unequal sharing / N with greater attraction / H with smaller attraction / $N^{\delta-}$ – $H^{\delta+}$** (2 × 3)

DESC: **hydrogen bonds between slightly neg O ($O^{\delta-}$) of water and H** of ammonia //
and **between slightly pos H ($H^{\delta+}$) of water and N** of ammonia (2 × 3)

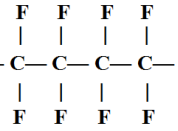
or

breaking of hydrogen bonds in water //
forming of hydrogen bonds between ammonia and water (2 × 3)

(c) **A**

(i) IDEN: **tetrafluoroethene / tetrafluoroethylene / C_2F_4** [*May be expanded.*] (4)

(ii) WHAT: **addition** (3)

(iii) DRAW:  **/ $-CF_2-CF_2-CF_2-CF_2-$** [*End bonds not reqd.*] (6)

(iv) GIVE: **first property // use of first // second property // use of second** (4 × 3)

PROPERTY	USE
Inert (unreactive, stable)	**Artificial blood vessels / containers / tubing / plumbing** tape
Temperature tolerant	**Cooking utensils (or named utensil)**
Hydrophobic (repellent, non-stick)	**Cooking utensils (or named utensil) / clothing (fabric, Gore-Tex)**
Corrosion resistant	**Artificial blood vessels / containers / tubing / plumbing** tape
Low friction	**Lubrication / bearings / gears**

B

OUTLINE: **decomposition of oxygen** molecule **into oxygen atoms (radicals) by** high-energy **ultraviolet (uv)** light **/ $O_2 \xrightarrow{uv} 2O^{\bullet}$ //**

reaction of oxygen atom (radical) with oxygen molecule forming ozone / **$O^{\bullet} + O_2 \rightarrow O_3$** (4 + 3)

WHY: **lack of** high-energy **ultra-violet (uv)** light / **oxygen not decomposed** (3)

(i) **chlorofluorocarbon**s **(cpds of C, F & Cl)** (3)

(ii) they are **stable (unreactive)** / **insufficient (lack of)** high-energy **ultraviolet (uv)** light / **insoluble in water** (3)

(iii) **refrigerant (fridges) / air-conditioning / aerosols / dry cleaning / solvents / fire extinguishers / expanded polymers (blowing agents) /** burger **cartons** (3)

(iv) NAME: **nitrogen(II) oxide (nitric oxide, nitrogen monoxide)** [*Formula unacceptable*] (3)

GIVE: **electrical discharge (lightning, spark plug) / car (aircraft)** engines / **exhaust gases (fumes)** / **micro-organisms (bacteria, microbes, fungi) /** traces produced in other **living organisms (plants, animals)** (3)