Leaving Certificate 2013

Marking Scheme

Chemistry

Higher Level
Note to teachers and students on the use of published marking schemes

Marking schemes published by the State Examinations Commission are not intended to be standalone documents. They are an essential resource for examiners who receive training in the correct interpretation and application of the scheme. This training involves, among other things, marking samples of student work and discussing the marks awarded, so as to clarify the correct application of the scheme. The work of examiners is subsequently monitored by Advising Examiners to ensure consistent and accurate application of the marking scheme. This process is overseen by the Chief Examiner, usually assisted by a Chief Advising Examiner. The Chief Examiner is the final authority regarding whether or not the marking scheme has been correctly applied to any piece of candidate work.

Marking schemes are working documents. While a draft marking scheme is prepared in advance of the examination, the scheme is not finalised until examiners have applied it to candidates’ work and the feedback from all examiners has been collated and considered in light of the full range of responses of candidates, the overall level of difficulty of the examination and the need to maintain consistency in standards from year to year. This published document contains the finalised scheme, as it was applied to all candidates’ work.

In the case of marking schemes that include model solutions or answers, it should be noted that these are not intended to be exhaustive. Variations and alternatives may also be acceptable. Examiners must consider all answers on their merits, and will have consulted with their Advising Examiners when in doubt.

Future Marking Schemes

Assumptions about future marking schemes on the basis of past schemes should be avoided. While the underlying assessment principles remain the same, the details of the marking of a particular type of question may change in the context of the contribution of that question to the overall examination in a given year. The Chief Examiner in any given year has the responsibility to determine how best to ensure the fair and accurate assessment of candidates’ work and to ensure consistency in the standard of the assessment from year to year. Accordingly, aspects of the structure, detail and application of the marking scheme for a particular examination are subject to change from one year to the next without notice.
**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

Section A

At least two questions to be answered from this section.

1. (a) WHY: 5; (b) IDENTIFY: 3; (c) WHAT: 3; (d) RINSE: $2 \times 3$, FILL: $3 \times 3$; (e) NAME: 3; (f) CALC: 6, (i) 3, (ii) 3, (iii) 3; (g) WHAT: 3; (h) WHY: 3.

2. (a) HOW: 5 or 3; (b) DESCRIBE: 3, 3, 6; (c) DESCRIBE: $4 \times 3$ or $2 \times 3$, $2 \times 3$; (d) WHICH: 2 $\times 3$, SOLVENT: 3, EXPLAIN: 6; (e) IDENTIFY: 3, STATE: 3 (or 6 for IDENTIFY and STATE given together).

3. (a) DEFINE: 5; (b) SUGGEST: 3; (c) STATE: (i) 3, (ii) 3; (d) STATE: $2 \times 3$; (e) HOW: 3, CALC: 9, HENCE: 6; (f) IDENTIFY: 6, DESCRIBE: 3, WHAT: 3.

Section B

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) WRITE: $2 \times 3$; (b) DEFINE: $2 \times 3$; (c) HOW: 6; (d) GIVE: $2 \times 3$; (e) WHEN: 6; (f) COMPLETE: $2 \times 3$; (g) WHAT: $2 \times 3$; (h) STATE: $2 \times 3$; (i) WHAT: 6; (j) WHAT: 6; (k) A WRITE: $2 \times 3$, B WRITE: $2 \times 3$.

5. (a) WHAT: 5; (b) USE: $5 \times 3$, EXPLAIN: $2 \times 3$, WHAT: 3, DESCRIBE: $2 \times 3$; (c) EXPLAIN: $2 \times 3$, GIVE: 3, WHAT: $2 \times 3$.

6. (a) DEFINE: 5; (b) (i) GIVE: $2 \times 3$, (ii) EXPLAIN: $2 \times 3$, DRAW: 3, (iii) PREDICT: 3, JUSTIFY: 3; (c) CALCULATE: 15; (d) (i) 3, (ii) 2 $\times 3$.

7. (a) DEFINE: 5; (b) EXPLAIN: 6; (c) SUGGEST: $2 \times 3$, EXPLAIN: $2 \times 3$; (d) DESCRIBE: $3 \times 3$; (e) DRAW: $3 \times 3$.

8. (a) EXPLAIN: 6, WHAT: 3, HOW: $2 \times 3$; (b) IDENTIFY: $3 \times 3$; (c) DESCRIBE: $4 \times 3$; (d) DRAW: 6, NAME: 3; (e) DRAW: 5.

9. (a) WHAT: 5, WHY: 3, STATE: $2 \times 3$; (b) EXPLAIN: (i) $2 \times 3$, (ii) 3; (c) WRITE: 6, CALCULATE: 12; (d) STATE: 3, IS: 3, JUSTIFY: 3.

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

(a) DISTINGUISH: $4 \times 3$, (i) 6, (ii) $2 \times 3$, (iii) $2 \times 3$.

(b) (i) DEFINE: 3, SHOW: $2 \times 3$, IDENTIFY: 3; (ii) WHAT: 9, WHAT: 4.

(c) (i) DEFINE: 6, (ii) GIVE: $2 \times 3$, (iii) GIVE: $2 \times 3$, (iv) WHAT: 7.

11. Answer any two of the parts (a), (b) and (c).

(a) DEFINE: $4 \times 3$, (i) DEDUCE: $2 \times 3$, WHAT: 3, (ii) WHAT: 3, (iii) EXPLAIN: $2 \times 3$.

(b) DEFINE: (i) & (ii) $4 \times 3$, GIVE: (i) 3, (ii) 3, CALCULATE: 12.

(c) Do part A or part B.

A (i) WHAT: 4, (ii) WHY: 3, (iii) SUGGEST: 3, (iv) WRITE: $2 \times 3$, (v) NAME: 3, NAME: 3.

B (i) DISTINGUISH: $2 \times 3$, (ii) EXPLAIN: $2 \times 3$, (iii) WHY: 3, (iv) GIVE: $2 \times 3$, GIVE: 4.
SECTION A

[At least two questions must be answered from this section]

QUESTION 1

(a) WHY: more oxygen \((O_2)\) would dissolve / would increase dissolved oxygen \((O_2)\)/ prevent more oxygen \((O_2)\) dissolving / increase oxygen \((O_2)\) concentration / altering oxygen \((O_2)\) / bubbles contain oxygen \((O_2)\) (5)

(b) IDENTIFY: manganese(II) sulfate / MnSO_4 [Correct formula with incorrect name: (0)] (3)

(c) WHAT: a brown (red, orange, yellow, iodine) solution [Accept “ppt dissolves” but not “brown ppt.”] (3)

(d) RINSE: rinse with deionised (distilled) water // rinse with a little of the thiosulfate solution // [Accept “rinse with thiosulfate.”] (2 × 3)

FILL: add solution to burette and clamp vertically / ensure burette is vertical // use a funnel to fill / remove funnel before adjusting to mark / mark at eye-level // open tap to fill jet (part below tap) // [Do not accept “fill the tap.”] [Do not accept “open tap and allow liquid to flow.”] use tap (or dropper) to set bottom of meniscus on zero mark [Accept “lower part of meniscus” but not “lower meniscus” for “bottom of meniscus.”] ANY THREE: (3 × 3)

(e) NAME: freshly-prepared starch solution (3)

(f) CALC: \(0.00047\) mol 1\(^{-1}\) [0.00047 gets (6) even if when rounded up to 0.0005.] (6)

\[
\begin{align*}
\frac{200 \times x}{1} &= \frac{9.4 \times 0.02}{2} \\
x &= \frac{0.00047}{3}
\end{align*}
\]

[No marks for formula alone.]

[If 0.0005 is used in the following calculations (−1)]

(i) \(0.000235\) mol 1\(^{-1}\) \(O_2\) [Accept 0.000235 – 0.00024] (3)

\[
0.00047 \div 2 = 0.000235
\]

(ii) \(0.00752\) g 1\(^{-1}\) \(O_2\) [Accept 0.0075 – 0.0077] (3)

\[
0.000235 \times 32 = 0.00752
\]

[Multiplying answer by 5 at any stage (−3)]

(iii) 7.52 ppm \(O_2\) [Accept 7.5 – 7.7] (3)

\[
0.00752 \times 1000 = 7.52
\]

(g) WHAT: there was almost (virtually) no (negligible, extremely low) dissolved oxygen \((O_2)\) in the water (3)

(h) WHY: biochemical (biological) reactions (photosynthesis, respiration, metabolism) occur / action of micro-organisms (bacteria, algae, diatoms) (3)
QUESTION 2

(a) HOW: named substance (ethanoic acid or ethanol) and named test reagent (material) // result (e.g. colour change, odour, gas evolved, etc)
[Named substance, reagent & result linked; ethanoic acid may be inferred.]

ethanoic acid: named indicator* with correct colour change [Only second colour reqd.]
[*Accept pH meter//(<7)] [*Univ. Ind. // colour observed] [*pH (indicator) paper // colour] [*Accept “phenolphthalein” but not “no colour change”.]
suitable metal (e.g. Mg) – gas evolved or metal dissolves (disappears)
[NB: alkali metals unsuitable]
carbonate or hydrogen carbonate [Accept common names] – [gas evolved
add alcohol (ethanol) + acid (H+, H₂SO₄) – fruity (ester) odour

not ethanol: suitable ox agent (acidified manganate(VII)*[ H⁺/MnO₄⁻]) – no colour change or no odour of ethanol
no gas evolved or metal does not dissolve (metal remains)
[NB: alkali metals unsuitable]
[allow acidified dichromate H⁺/Cr₂O₇²⁻][*Accept “permanganate.”]
add alcohol (ethanol) + acid (H⁺, H₂SO₄) – no fruity (ester) odour

(b) DESCRIBE: with named reagent (3) // colour before (3) // colour after (6) [Reagent & colours linked.]

bromine (Br₂) soln // brown (red, orange, yellow) // colourless (disappears) [Not “clear”.]
cis-3-dichloro-2-propenyl alcohol (2-propen-1-ol) // trans-2-dibromo-1-propene // brown // colourless
[Not “clear”.]*

acidified manganate(VII)* [H⁺/MnO₄⁻] soln // purple (pink, violet) // colourless (disappears) [Not “clear”.][* Accept “permanganate.”]

(c) DESCRIBE:

Paper chromatography [Lid not required in diagram.]
apply mixture using dropper (capillary tube) / spot on paper // slightly (just, c.2 cm) above (below if solvent at top) eluent* // in tank (beaker, other suitable container) with eluent* // elution described / solvent moves up** (down) separating components
[The elution stage must be described but separation may be shown.]
The elution stage may be shown on a second diagram which shows the solvent front and the separation.]

(4 × 3)

Thin-layer chromatography [Lid not required in diagram.]
apply mixture using dropper (capillary tube) / spot on plate // slightly (just, c.2 cm) above eluent* // in tank (beaker, other suitable container) with eluent* // elution described / solvent moves up** separating components
[The elution stage must be described but separation may be shown.]
The elution stage may be shown on a second diagram which shows the solvent front and the separation.]

(4 × 3)

[**Accept “soaks up” or “absorbs” for “moves up”.

**In part (a)
and in part
(b) do not
apply linkage
when
acidification
of a correct
reagent is
omitted

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**Column chromatography**

dissolve mixture in eluent* //
add to column / add mixture to column //
add eluent*

continue to add eluent* so that it flows through column //
separation of components occurs / bands shown on diagram

[* Accept "mobile phase," "solvent" or "named solvent" for "eluent"]

[If there is no diagram, or if the diagram does not have at least one label, deduct 3 marks, but only if at least 3 marks have been awarded.]

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**(d) WHICH:**

B //

higher melting point / with narrower range / (A has lower melting point / A has wider range)

**SOLVENT:**

water

**EXPLAIN:**

very (quite) soluble in hot but slightly (less) soluble [not “insoluble”] in cold /
much more soluble in hot (much less soluble in cold)

---

**(e) IDENTIFY:**

end of safety tube above (not under) water surface in flask / no steam trap / no gauze

or

**STATE:**

have end of tube under water* in flask / put in steam trap* / put in (use) gauze*

[*Stated or shown: (6)]

[Mark IDENTIFY and STATE independently and award the higher of the two marks.]
QUESTION 3

(a) **DEFINE:** heat change when the **numbers of moles of reactants in the balanced equation** react completely / heat change for **reaction according to balanced equation**

(b) **SUGGEST:** polystyrene / plastic / styrofoam / paper / cardboard / other named good insulating material [Not “glass”. Do not accept vessel on its own e.g. “cup” or “beaker].

(c) **STATE:**

(iii) **more accurate (accuracy)** / delivers the measured volume (doesn’t leave part of the measured volume behind on sides) // [not “easier to read”].

(ii) slow addition / **two 50 cm³ burettes needed** (burette to measure 75 cm³ usually not available in school laboratory) / difficult to measure 75 cm³ (2 × 3)

[Do not accept “NaOH causes tap to stick”].

(d) **STATE:** sensitive (precise, accurate, reading to 0.2°C or better [not “digital” alone] thermometer (or else a temperature sensor or temperature probe) // add quickly // **avoid splashing** // cover quickly (immediately) // **stir (mix)** // after addition plot temperature at intervals and get highest temperature by extrapolating back to time of mixing ANY TWO: (2 × 3)

(e) **HOW:** 0.075 mol HCl

\[
\frac{75 \times 1}{1000} = 0.075
\] (3)

**CALC:** 4.347 (4.35) kJ

\[
\begin{align*}
\text{Mass: } & 75 + 75 = 150 \text{ cm}^3 / = 150 \text{ g} / = 0.15 \text{ kg} \\
\text{Temp rise: } & 20.9 - \frac{(15.0+13.0)}{2} = 6.9 \text{ K} \\
\text{Heat prod: } & 0.15* \times 4.2** \times 6.9 = 4.347 (4.35) \text{ kJ}
\end{align*}
\]

[*Number must be <1 to be accepted as kg for consequential marking.]

[Unit (kg) not required but **where 4200 used, the answer must include the unit joule (J)]

**HENCE:** −57.96 (−58) kJ

\[
\frac{4.347}{0.075} = - (3) \quad 57.96
\] (3)

(f) **IDENTIFY:** corrosive / burns skin / damages eyes

[Accept harmful, irritant, causes rash or itch, etc]

[Do not accept “caustic” or “toxic” but these do not cancel correct answers.]

**DESCRIBE:** / test tube(s) **dripping (pouring)** onto surface / 

[IDENTIFY & DESCRIBE unlinked]

**WHAT:** very small temperature rise (change) / small heat change / hard to measure temperature rise (heat change) accurately / greater percentage error

[Do not accept “heat of reaction is smaller.”]
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) WRITE: \[ 1s^22s^22p^6 \]
\[ 3s^23p^63d^{10}4s^2 / 3s^23p^64s^23d^{10} \]

[Accept \( p_x^2p_y^2p_z^2 \) for \( p^6 \). Allow with subscripts.]

[Allow (3) for \( p_x^2p_y^2p_z^2 \) but otherwise correct][Allow \( Ar \) instead of \( 1s^22s^22p^63s^23p^6 \).]

(2 \times 3)

(b) 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

[Mass of 1 mole of element when 1 mole of carbon-12 is taken as 12 grams.]

(2 \times 3)

(c) HOW:

\[ 0.14 \div 14 = 0.01 \text{ mol} \times 6 \times 10^{23} = 6 \times 10^{21} \text{ atoms} \]

(3)

\[ 6 \times 10^{21} \text{ atoms} \times 8 = 4.8 \times 10^{22} \text{ neutrons} \]

(3)

(d) GIVE: tetrahedral // 109° 28' [Accept 109 – 109.5°]

[Accept good diagram]

(2 \times 3)

(e) WHEN: CuO

\[
\begin{align*}
\text{mass of copper} &= 1.27 \text{ g}; \quad \text{mass of oxygen} = 1.59 - 1.27 = 0.32 \\
\frac{0.27}{63.5} &= 0.02; \quad \frac{0.32}{16} = 0.02 \\
&\Rightarrow \text{empirical formula} = \text{CuO}
\end{align*}
\]

(3)

(f) COMPLETE:

\[ C_2H_5OH + Na \rightarrow C_2H_5ONa + \frac{1}{2}H_2 / 2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa + H_2 \]

[Full equation required.]

FORMULAS: (3) BALANCING: (3)

(g) WHAT: freshly-prepared iron(II) sulfate (FeSO₄) soln // conc sulfuric acid (H₂SO₄)

[Accept “ferrous sulfate.”]

[Accept formula: H₂SO₄ as conc.]

(2 \times 3)

(h) STATE: volume varies directly with kelvin (absolute) temperature / \( V \propto \frac{T}{T_2} = k / \frac{V_1}{T_1} = \frac{V_2}{T_2} / \)
\[ V \propto T / \text{gas expands by} \frac{1}{273} \text{ of volume at } 0 \degree C \text{ for every } \degree C \text{ rise in temp} // \]
for a definite mass of gas at constant pressure [Capital T essential in formulas.]

(2 \times 3)

(i) WHAT: oxidation / aeration / digestion (breakdown, decomposition) / biological (biochemical) action / by micro-organisms (bacteria) / by activated sludge

(6)

(j) WHAT: reactant(s) (substrate) and catalyst in different phase(s) / boundary between reactants and catalyst

[Allow 3 marks only if “states” used for “phases”. No marks for an example.]

(6)

(k) A WRITE:

\[ \text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3 \]

FORMULAS: (3) BALANCING: (3)

or

B WRITE:

\[ \text{O}^\cdot + \text{O}_2 \rightarrow \text{O}_3 \] [Accept if O₂ → 2 O^\cdot is given before it.]

FORMULAS: (3) BALANCING: (3)
QUESTION 5

(a) WHAT: an element cannot be broken (split, divided) into anything simpler* an element is a simple substance [*Do not accept “smaller.” Accept “further” and “simpler by chemical means.”] (5)

(b) USE: the electron in a hydrogen atom occupies (is restricted to) fixed energy levels (fixed energy values or discrete energies) // in the ground state electrons occupy the lowest available energy levels // the electron can move (jump, become excited) to a higher energy level if it receives a certain amount of energy (heat, light, a photon of energy) // the energy (photon) absorbed must exactly equal the energy difference between ground state (lower level) and excited state (higher level) / absorbing light (energy, photon) according to \( E_2 - E_1 = hf (hv) \), \([E_2 - E_1 \text{ symbols must be explained}] //

excited state unstable / excited state temporary / electron falls back to a lower level //

emitting (giving out) the excess energy in the form of a photon of light (hf, hv) //

emitting (giving out) light* according to \( E_2 - E_1 = hf (hv) \), \([E_2 - E_1 \text{ symbols must be explained}] [Accept “energy” for “light” if f(υ) is explained as frequency.] ANY FIVE: (5 × 3)

[Marks may be awarded where the required information is clearly provided in diagrams.]

EXPLAIN: metal atoms of different elements have different sets of energy levels (values) / different electron configurations (arrangement), different numbers of electrons in shells / individual (different, characteristic) set of electron transitions for each metal //

therefore they emit different (characteristic, unique, their own) frequencies (wavelengths, not colours) of light /

therefore they have different (characteristic, unique, their own) spectra (2 × 3)

(c) EXPLAIN not possible to measure (find, know, get, etc,) the exact position (location) //

and momentum (energy, velocity, speed) of electron (particle, named particle) in an atom simultaneously (at the same time) [“position” and “momentum” are interchangeable.] (2 × 3)

GIVE: wave nature (properties) of electron (wave-particle duality) / higher resolution spectra / sublevels / Zeeman effect (splitting of spectral lines) / electron spin / failure of theory with higher elements (except for hydrogen, with multi-electron systems) [Do not accept “orbitals.”] ANY ONE: (3)

WHAT: region (space, volume but not “area” or “place”) around the nucleus of an atom //

where there is a 99% (high) probability (possibility) of finding an electron / where electron most likely to be (has a high possibility of being) found

or

space occupied by electron // described by solution of Schrödinger equation (2 × 3)
QUESTION 6

(a) **DEFINE:** measure of tendency (likelihood) to auto-ignite (pre-ignite, ignite early, ignite before spark, knock, pink) / number representing ability (tendency, measure) to resist auto-igniting (ditto) / number 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 / 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

(b) (i) **GIVE:** A pentane // B 2-methylbutane // [Number not required but no marks if incorrect number used.]

(ii) **EXPLAIN:** changing to different structure(s) {structural formula(s)} / different arrangement of atoms / changing straight to branched and vice versa / changing branched to more branched and vice versa / hydrocarbons becoming branched [Do not accept “hydrocarbons becoming straight”.] // that have the same molecular* formula / same atoms [* Not “chemical”.] (2 × 3)

**DRAW:**

\[
\begin{align*}
C(CH_3)_4 & \quad \text{or} \\
(CH_3)_3C(CH_3) & \quad \text{or} \\
(CH_3)_2C(CH_3)_2 &
\end{align*}
\]

In the fully expanded formula the hydrogen atoms may be omitted. The diagram on the right requires some indication of non-planarity.

(iii) **PREDICT:** B / 2-methylbutane // [Accept the formula given for B in part (b) (i) above.]

**JUSTIFY:** shorter chain / branch (A has longer chain / no branch) (2 × 3)

(c) **CALCULATE:**

\[
\begin{align*}
\text{CaC}_2 & \quad \rightarrow \quad \text{Ca} \quad + \quad 2C \quad \Delta H \quad = \quad 59.8 \text{ kJ} \\
2\text{H}_2\text{O} & \quad \rightarrow \quad 2\text{H}_2 \quad + \quad \text{O}_2 \quad \Delta H \quad = \quad 571.6 \text{ kJ} \\
2\text{C} \quad + \quad \text{H}_2 & \quad \rightarrow \quad \text{C}_2\text{H}_2 \quad \Delta H \quad = \quad 227.4 \text{ kJ} \\
\text{Ca} \quad + \quad \text{O}_2 \quad + \quad \text{H}_2 & \quad \rightarrow \quad \text{Ca(OH)}_2 \quad \Delta H \quad = \quad -985.2 \text{ kJ}
\end{align*}
\]

\[
\begin{align*}
\text{CaC}_2 + 2\text{H}_2\text{O} & \quad \rightarrow \quad \text{C}_2\text{H}_2 \quad + \quad \text{Ca(OH)}_2 \quad \Delta H \quad = \quad -126.4 \text{ kJ}
\end{align*}
\]

Equations not required. [Award (3) for 126.4 (+126.4) unless it can be seen to merit more.]

\[
\begin{align*}
\Delta H_{\text{reaction}} &= \Sigma \Delta H_{\text{f(products)}} - \Sigma \Delta H_{\text{f(reactants)}} \\
&= 227.4 \text{(3)} - 985.2 \text{(3)} - \{ -59.8 \text{(3)} - 2 \times 285.8 \text{(3)} \} \\
&= 227.4 \text{(3)} - 985.2 \text{(3)} + 59.8 \text{(3)} + 571.6 \text{(3)} \\
&= -126.4 \text{ kJ (3)}
\end{align*}
\]

(d) (i) **sigma (σ) bonds / single covalent / a shared pair of electrons / end-on (head-on) overlap of singly-occupied atomic orbitals** (3)

(ii) **sigma (σ) bonds / single covalent / a shared pair of electrons / end-on (head-on) overlap of singly-occupied atomic orbitals (sp² hybrids) / identical carbon-to-carbon bonds / intermediate between single and double //**

also **pi (π) bonds / lateral (sideways) overlap of singly-occupied p orbitals / delocalised electron cloud / delocalised electrons** (2 × 3)
QUESTION 7

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

(b) EXPLAIN: they are ionic compounds (ions mentioned or shown in equation) // ions free in solution // bonds (compounds) already broken // dissociated // ions only need to collide // ions ready to collide // immediate (fast) collisions  

(c) SUGGEST: increased pressure (concentration) // increased* temperature [accept “heat.”] // addition of a catalyst [*Do not accept “low (decrease in) temperature”.] ANY TWO:  

EXPLAIN: pressure (concentration): closer molecules means more collisions per unit time //  

temperature: increases energy of molecules / more collisions reach activation energy / more effective collisions / slightly more collisions per unit time //  

catalyst: lowers activation energy / more effective collisions / stretches (loosens, weakens) bonds / forms activated complex / higher concentration (reactants closer) on surface of catalyst / orient reactants correctly / provides active sites ANY TWO:  

[The answers to SUGGEST and EXPLAIN must be linked.]  

(d) DESCRIBE: place* the thiosulfate soln (the HCl) in a vessel over a cross (mark) on a white surface // add* the HCl (the thiosulfate soln) and start a stopclock (stopwatch, timer, named suitable timing device) // [Do not accept “watch” or “clock.”]  

note the time when the cross becomes invisible when viewed through the solution  

[* Award (2 × 3) for “mix the two solutions over cross (mark) and start timing device”]  

DESCRIBE: repeat the above procedure for each of the given solutions //  

find the reciprocals of the times (find the 1/t values) to get the rates /  

plot 1/t against concentration //  

dividing rates by corresponding thiosulfate concentrations (or vice versa) gives a constant /  

rate = k / conc rate = k /  

plot of rate against concentration gives a straight line through the origin (0, 0)  

[Marks obtainable from a correct sketch graph with axes labelled.]  

(e) DRAW:  

exothermic reaction shown //  

(i) activation energy (E_A) //  

(ii) heat of reaction (ΔH)  

The marks for (i) and (ii) may be given for an endothermic reaction diagram.
QUESTION 8

(a) EXPLAIN: general formula // differ by CH₂ // same functional group // similar chemical properties // gradation in physical properties // similar method of preparation [Accept “uniform chemical type” for “similar chemical properties”]. ANY ONE: (6)

WHAT: addition / hydrogenation / reduction

HOW: planar (from 120° bond angle*) // to tetrahedral* (to 109° 28’ / 109.5°) [*For the tetrahedral angle, accept 109 – 109.5°] (2 × 3)

[If explained in terms of bond angles the numbers alone are not sufficient but the words “bond angle” are only required once.]

(b) IDENTIFY: (i) chlorine (Cl₂) // [Do not accept Cl.]

(ii) hydrogen chloride (HCl) //

(iii) chlorine (Cl₂) [Do not accept Cl.] (3 × 3)

(c) DESCRIBE: polarisation of chlorine molecule by double bond / (Clδ+ – Clδ–) // [*Line essential] followed by heterolytic fission of chlorine molecule (Cl₂) / Cl₂ → Cl⁺ + Cl⁻ // [* Bond must not be shown.]

addition (attraction, bonding) of Cl⁺ (Clδ+ – Clδ–) to the double bond // [Do not accept addition of Clδ+; on a diagram Clδ+ – Clδ– must be oriented correctly.]

forming a localised carbonium ion* (carbocation*) [Accept positive carbon (C⁺)]. (chloronium ion) /

addition of chloride ion (Cl⁻) to the intermediate (named intermediate) to give 1,2-dichloroethane ANY FOUR: (4 × 3)

[In each step, an incorrect point cancels a correct point e.g. one incorrect, one correct (0), one incorrect, two correct (3), two incorrect, two correct (0).]

[Points may be got from suitable diagrams. Where appropriate, allow correct use of curly arrows, e.g

[If addition of HCl is described, award (3) for carbonium ion (not chloronium ion – but do not cancel). Award (3) for addition of chloride ion to carbonium ion.]

(d) DRAW: CH₂ = CHCl

NAME: 1-chloroethene / chloroethylene / monochloroethene / monochloroethylene / vinyl chloride (3)

(e) DRAW: 

[Accept if formula in brackets with subscript n outside.]

[End bonds not required.]
QUESTION 9

(a) WHAT: a state in which the rate of the forward reaction equals the rate of the reverse (backward) reaction / a state where the concentrations of reactants and products are maintained (do not change) at the same levels (5)

WHY: reaction has not stopped (is continuing) / forward & reverse reaction(s) still occurring (3)

STATE: if a system at equilibrium is subjected to a stress* (is disturbed) // it tends (attempts, alters, moves) to oppose (minimise, relieve) the stress* (disturbance, influence) [*The term “stress” may be replaced by “pressure, temp, conc” but only if all three are given. Do not accept “force” for stress.]

(b) EXPLAIN: (i) decrease // reaction shifts forward (to right or red side) to oppose stress (decrease CNS− conc) [Do not accept “according to Le Chatelier’s principle” for “to oppose stress.”] (2 × 3) [Cancelling applies for a contradiction in either direction. Accept “compensate for”, for “oppose.”]

(ii) equilibrium in solution / liquid phase / liquid (solution) not compressible / no gases involved [Accept “in aqueous solution.”]

(c) WRITE: [Fe(CNS)2+] [Fe3+][CNS−] [Accept FeCNS2+ for Fe(CNS)2+.] [Expression inverted (0).]

CALCULATE: 138.87 (138.9, 139) M⁻¹ (12)

<table>
<thead>
<tr>
<th>Fe³⁺</th>
<th>+</th>
<th>CNS⁻</th>
<th>⇌</th>
<th>Fe(CNS)²⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start (M)</td>
<td>1.0 × 10⁻³</td>
<td>1.0 × 10⁻³</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Equil (M)</td>
<td>8.9 × 10⁻⁴ (3)</td>
<td>Ms the same (3)</td>
<td>1.1 × 10⁻⁴ mol</td>
<td></td>
</tr>
</tbody>
</table>

\[ K_c = \frac{1.1 \times 10^{-4}}{(8.9 \times 10^{-4})^2} \] [Accept correct use of an incorrect \( K_c \) expression from (c) WRITE.] (3)

\[ = 138.87 (138.9, 139) \] (3)

(d) STATE: smaller (3)

IS: endothermic (3)

JUSTIFY: cooling (ice-water) shifts in the backward (left or yellow side) direction for this reaction, therefore backward (left) is exothermic (gives out heat) / cooling always shifts in exothermic direction (side that releases heat) which is the backward (left or yellow side) direction for this reaction [IS & JUSTIFY are linked.] (3)
QUESTION 10: Answer any two of the parts (a), (b) and (c).

(a) DISTINGUISH: intramolecular: forces between atoms in (within, inside) molecules // intermolecular: forces between molecules (4 + 3) [Marks may be awarded for diagrams that clearly show the necessary information.]

(i) hydrogen smaller {has fewer (two) electrons} [Accept “lighter”.] // therefore weaker (less) intermolecular (van der Waals, dispersion, London, dipole-dipole) forces (attractions, interactions) (6)

[N.B. Answer could be given in terms of oxygen (N.B. 16 electrons).]

(ii) iodine pure covalent (non-polar) // water a polar solvent // intermolecular (van der Waals, etc.) forces (attractions, interactions) between iodine and water very weak (2 × 3)

(iii) charge on rod attracts // opposite charge on polar (dipole of) water molecule (2 × 3)

(b) (i) DEFINE: increase in oxidation number (3)

SHOW: 8Al + 3Fe₃O₄ → 4Al₂O₃ + 9Fe
Al increased (oxidised) // 0 to +3 (3) // Fe decreased (reduced) // +2½ (2½)* to 0 (2 × 3)

[Accept Fe₃O₄ for Fe.]

[Change in oxidation numbers must be shown in some form.]

IDENTIFY: Al (aluminium) (3)

(ii) WHAT: 432 g

1008 g Fe ÷ 56 = 18 mol (3) ≡ 16 mol Al (3) × 27 = 432 g (3)

16 mol Al ≡ 8 mol Al₂O₃ (2) × 102 = 816 g (2)

Marks may be awarded to candidates for use of correct ratio of masses based on Mr.
DEFINE:
spontaneous random decay of (disintegration of, decomposition of, breaking up of, change within) a nucleus* releasing α, β or γ radiation

or
spontaneous random emission of radiation (radiant energy, rays, particles) from unstable nuclei due to decay of (disintegration of, etc.) a nucleus* [*Do not accept “atom” for “nucleus”.*]

GIVE:

(ii) chemical: involves electrons // no change to nucleus (no release of nuclear energy (radiation, rays, particles)) // bonds (named bonds, molecules) broken (formed) // elements unchanged (not transmuted) // mass conserved // energy comes from bonds

nuclear: electron cloud (electrons) not involved // nuclear change (release of energy (radiation, rays, particles) from nucleus) // no bond breaking (forming) // new elements (transmutation) // mass not conserved // energy comes from mass

[Point given for chemical, assume opposite for nuclear, & vice versa.] ANY TWO: (2 × 3)

(iii) negative* (minus, –) charge // negligible mass (mass of electron) // high speed // moderately penetrating (less penetrating than γ, more penetrating than α, penetrate skin, penetrate paper, stopped by 2 – 5 mm (thin sheet of) aluminium) // moderately ionising (less ionising than α, more ionising than γ) // damage body cells (organs) DNA, cause cancer, cause mutations) // deflected by electric fields // deflected by magnetic fields // cause electroluminescence (fluorescence, phosphorescence) [*Allow “positive” but only if positron is mentioned.] ANY TWO: (2 × 3)

(iv) WHAT: one-eighth / ⅛ / 0.125 / 12.5% [Accept 0.994 or 99.4% or $\frac{994}{1000}$ (7)]
QUESTION 11: Answer any two of the parts (a), (b) and (c).

(a) DEFINE: minimum energy to remove most loosely-bound (highest energy, outermost) electron //
from an isolated (gaseous) atom in its ground (lowest energy) state / from 1 mole of isolated (gaseous) atoms in their ground (lowest energy) state

(i) DEDUCE: B is helium // P is sulfur (sulphur)

WHAT: 900

(ii) WHAT: R (argon) has (by losing an electron S (potassium) gets) stable outer octet of electrons {noble gas configuration, full outer sublevel (subshell), outer 3p^6} / S has outer electron further from nucleus [in a new main level (shell), / S more screened] / S’s electron removed from next (4th) main level (shell) / S has one electron in outer main level (shell) //

["R has full outer shell" (0 marks) but doesn’t cancel a correct point]

(iii) EXPLAIN: a half-full p sublevel has associated stability / paired electrons in a p orbital unstable //

H (oxygen) has lower first ionisation energy (loses electron more easily) because it has a less stable electron configuration than G / is one electron above (away from) stability / 2p_x^22p_y^1 or 2p^3 or 2p \[\uparrow \downarrow \downarrow \] / loss of electron from H gives half-full 2p

G (nitrogen) has higher first ionisation energy (loses electron less easily) because it has a more stable electron configuration than H / 2p_x^12p_y^12p_z^1 or 2p^3 or 2p \[\downarrow \downarrow \downarrow \] / half-full 2p-sublevel

(b) DEFINE: (i) Arrhenius: dissociates to produce hydroxyl (hydroxide) ions (OH^-) in aqueous solution (water) //
(ii) Brønsted-Lowry: proton (hydrogen ion, H^+) acceptor

GIVE: (i) H_2PO_4^- // (ii) PO_4^{3-}

CALCULATE: 11.28 (11.3)

\[
\begin{array}{l}
\text{7 g of NH}_4\text{OH} = 7 \div 35 = 0.2 \text{ mol} \Rightarrow 0.2 \text{ M NH}_4\text{OH} \\
[\text{OH}^-] = \sqrt{1.8 \times 10^{-5} \times 0.2} / 1.9 \times 10^{-3} = 2.72 (2.7) \\
\text{pOH} = -\log 1.9 \times 10^{-3} = 2.72 (2.7) \\
\text{pH} = 14 - 2.72 (2.7) = 11.28 (11.3) \\
\end{array}
\]

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\text{pH} = 14 - 2.72 (2.7) = 11.28 (11.3) \\
\end{array}
\]
(c) Answer either part A or part B.

A

(i) WHAT: production of chemical change (reaction, decomposition) when electricity [electrical energy (current)] passes through an electrolyte (ionic melt, ionic solution) [Do not accept “chemical change produced by electrical energy (current)”].

(ii) WHY: so that ions are free to move

(iii) SUGGEST: platinum (Pt) / carbon (C, graphite)

(iv) WRITE: $\text{Pb}^{2+} + 2e^- \rightarrow \text{Pb}$

\[
\begin{align*}
2\text{Br}^- & \rightarrow \text{Br}_2 + 2e^- / 2\text{Br}^- - 2e^- \rightarrow \text{Br}_2 / \\
\text{Br}^- & \rightarrow \frac{1}{2}\text{Br}_2 + e^- / \text{Br}^- - e^- \rightarrow \frac{1}{2}\text{Br}_2
\end{align*}
\]

FORMULAS: (3) BALANCING: (3)

(v) NAME: sodium / aluminium // [Name required – not formula.]

NAME: sodium from sodium chloride / aluminium from aluminium oxide (alumina)* (2 × 3) [* Do not accept “bauxite” for “alumina.”] [Name required – not formula.]

[Some other possibilities: lithium from lithium chloride; magnesium from magnesium chloride, magnesite or dolomite; calcium from calcium chloride.]

B

(i) DISTINGUISH: raw materials: used to produce feedstock // feedstock: materials (reagents, chemicals, substances) used in the process (reaction) / used to make the industrial product

(ii) EXPLAIN: fixed costs // must be paid regardless of level of production [Or accept: variable costs // as wages (salaries) differ from person to person (from time to time) / differ between temporary and permanent staff / wage rises / drops due to recession / workers on different contracts (2 × 3)]

(iii) WHY: they are chemically unreactive (inert, stable, resistant to corrosion) / hard wearing / cheap / easy to clean / can be moulded (shaped)

(iv) GIVE: batch: versatile (usable for diff. processes / usable to make diff. products) / suit seasonal products / usable for trial runs / small quantities can be economically produced / low cost of plant / low maintenance costs / suitable for slow reactions //

contin: can run for long periods / suitable for large scale production / long periods between maintenance / small danger of contamination

GIVE: ammonia: availability of natural gas (methane, CH₄) / good rail (road) link / near port / skilled workforce available / near university (third-level)

nitric acid: good rail (road) link / river (Avoca) water for cooling / near port / skilled workforce available / near university (third-level)

periclase: near sea / availability of limestone / river (Boyne) nearby / good road (rail) link / port access / skilled workforce available / near university (third-level) / rotary kilns from previous industry (4)
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