Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2013

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

Section A

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

1.   *(a)* WHY: 5; *(b)* IDENTIFY: 3; *(c)* WHAT: 3; *(d)* RINSE: 2×3, FILL: 3×3; *(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: 4×3 *or* 2×3, 2×3; *(d)* WHICH: 2×3,
     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: 2×3; *(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: 2×3; *(b)* DEFINE: 2×3; *(c)* HOW: 6; *(d)* GIVE: 2×3; *(e)* WHEN: 6; *(f)* COMPLETE: 2×3;
     (g) WHAT: 2×3; *(h)* STATE: 2×3; *(i)* WHAT: 6; *(j)* WHAT: 6; *(k)* **A** WRITE: 2×3, **B** WRITE: 2×3.

5.   *(a)* WHAT: 5; *(b)* USE: 5×3, EXPLAIN: 2×3, WHAT: 3, DESCRIBE: 2×3; *(c)* EXPLAIN: 2×3, GIVE: 3,
     WHAT: 2×3.

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

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

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

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

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

     (a) DISTINGUISH: $4 + 3$, *(i)* 6, *(ii)* 2×3, *(iii)* 2×3.

     (b) *(i)* DEFINE: 3, SHOW: 2×3, IDENTIFY: 3; *(ii)* WHAT: 9, WHAT: 4.

     (c) *(i)* DEFINE: 6, *(ii)* GIVE: 2×3, *(iii)* GIVE: 2×3, *(iv)* WHAT: 7.

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

     (a) DEFINE: $4 + 3$, *(i)* DEDUCE: 2×3, WHAT: 3, *(ii)* WHAT: 3, *(iii)* EXPLAIN: 2×3.

     (b) DEFINE: *(i)* & *(ii)* $4 + 3$, 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: 3, 2×3, *(v)* NAME: 3, NAME: 3.

         B *(i)* DISTINGUISH: 2×3, *(ii)* EXPLAIN: 2×3, *(iii)* WHY: 3, *(iv)* GIVE: 2×3, GIVE: 4.

SECTION A

[At least <u>two</u> 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   (3)
[Accept "ppt dissolves" but not "brown ppt."]

(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 l^{-1} *[0.00047 gets (6) even if when rounded up to 0.0005.]*   (6)

$$\frac{200 \times x}{1} = \frac{9.4 \times 0.02}{2} \quad (3)$$
$$x = 0.00047 \quad (3)$$

[No marks for formula alone.]

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

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

$$0.00047 \div 2 = 0.000235 \quad (3)$$

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

$$0.000235 \times 32 = 0.00752 \quad (3)$$

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

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

$$0.00752 \times 1000 = 7.52 \quad (3)$$

(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.]   (5 or 3)

<table>
<tr><td rowspan="2">In part (a)
and in part
(b) do not
apply linkage
when
acidification
of a correct
reagent is
omitted</td><td>ethanoic acid:</td><td>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 hydrogencarbonate [Accept common names] – [gas evolved
add alcohol (ethanol) + acid (H$^+$, H$_2$SO$_4$) – fruity (ester) odour</td></tr>
<tr><td>not ethanol:</td><td>suitable ox agent (acidified manganate(VII)*[H$^+$/MnO$_4^-$]) – no colour
change or no odour of ethanal
no gas evolved or metal does not dissolve (metal remains)
[NB: alkali metals unsuitable]
[allow acidified dichromate H$^+$/Cr$_2$O$_7$ $^{2-}$][*Accept "permanganate."]
add alcohol (ethanol) + acid (H$^+$, H$_2$SO$_4$) – no fruity (ester) odour</td></tr>
</table>

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

> **bromine (Br$_2$)** soln // **brown (red, orange, yellow)** // **colourless (disappears)** *[Not*
> *"clear".]*
> **acidified manganate(VII)*** **[H$^+$/MnO$_4^-$]** soln // **purple (pink, violet)** // **colourless**
> **(disappears)** *[Not "clear" .][* Accept "permanganate."]*

(c) DESCRIBE:
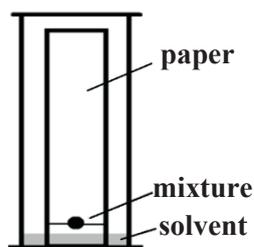
<u>*Paper chromatography*</u>   *[Lid not required in diagram.]*
apply mixture using dropper (capillary tube) / spot on paper //
slightly (just, c.2 cm) above (below if solvent at top) **eluent* //**
in tank (beaker, other suitable container) with **eluent* //**
elution described / solvent moves up (down) 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)

or
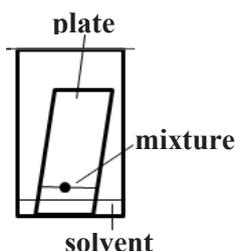
<u>*Thin-layer chromatography*</u>   *[Lid not required in diagram.]*
apply mixture using dropper (capillary tube) / spot on plate //
slightly (just, c.2 cm) above eluent* //
in tank (beaker, other suitable container) with **eluent* //**
elution described / solvent moves up separating components**
[The 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".]*
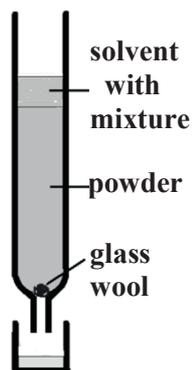
Column chromatography
dissolve mixture in eluent* //
add to column /add mixture to column //
add eluent* (2 × 3)
continue to add eluent* so that it flows through column //
separation of components **occurs / bands shown on diagram** (2 × 3)
[* Accept "mobile phase," "solvent" or "named solvent" for "eluent" .]

[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.]

(d) WHICH: **B //**

higher melting point / with narrower range / (A has lower melting point / A has wider range) (2 × 3)

SOLVENT: **water** (3)

EXPLAIN: **very (quite) soluble in hot** but **slightly (less) soluble** *[not "insoluble"]* **in cold /
much more soluble in hot (much less soluble in cold)** (6)

(e) IDENTIFY: end of safety **tube above (not under) water** surface in flask / **no steam trap / no gauze** (3)

or

STATE: have end of **tube under water*** in flask / **put in steam trap* / put in (use) gauze*** (6)
[*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** (5)

(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".]* (3)

(c) STATE: *(i)* **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 cm^3 burettes **needed (burette to measure 75 cm^3** usually **not available** in school laboratory) / **difficult to measure 75 cm^3** (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 (3)

$$\frac{75 \times 1}{1000} \quad = \quad 0.075 \qquad (3)$$

CALC: **4.347 (4.35)** kJ (9)

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

[* 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 (6)

$$\frac{4.347}{0.075} = \quad - \quad (3) \qquad 57.96 \qquad (3)$$

(f) IDENTIFY: **corrosive / burns skin / damages eyes** (6)
[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** / / cross

[IDENTIFY & DESCRIBE unlinked] (3)

WHAT: very **small temperature rise (change) / small heat change / hard to measure** temperature rise (heat change) **accurately / greater percentage error** (3)
[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: **$1s^2 2s^2 2p^6$ //**

$3s^2 3p^6 3d^{10} 4s^2$ / $3s^2 3p^6 4s^2 3d^{10}$ (2×3)

[Accept $p_x^2 p_y^2 p_z^2$ for p^6. Allow with subscripts.]

[Allow (3) for $p_x^2{}_y^2{}_z^2$ but otherwise correct][Allow Ar instead of $1s^2 2s^2 2p^6 3s^2 3p^6$.]

(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 (2×3)

[Mass of 1 mole of element when 1 mole of carbon-12 is taken as 12 grams. (3)]

(c) HOW: **4.8×10^{22}** neutrons (6)

$0.14 \div 14 = 0.01$ mol $\times 6 \times 10^{23} = 6 \times 10^{21}$ atoms	(3)
6×10^{21} atoms $\times 8 \qquad = 4.8 \times 10^{22}$ neutrons	(3)

(d) GIVE: **tetrahedral // 109° 28'** *[Accept 109 – 109.5°]* (2×3)

[Accept <u>good</u> diagram]

(e) WHEN: **CuO** (6)

mass of copper = 1.27 g; mass of oxygen = 1.59 – 1.27 = 0.32	
$\frac{1.27}{63.5} = 0.02$; $\frac{0.32}{16} = 0.02$	(3)
$\Rightarrow$ empirical formula = CuO	(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 ($FeSO_4$)** soln // **conc sulfuric acid (H_2SO_4)** (2×3)

[Accept "ferrous sulfate."]

[Accept formula: H_2SO_4 as conc.]

(h) STATE: **volume varies directly with kelvin (absolute) temperature** / $\frac{V}{T*} = k$ / $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ /

$V \propto T$ / **gas expands by** $^1/_{273}$ **of volume at 0 °C for every °C rise in temp //**

for a definite **mass** of gas at **constant pressure** *[*Capital T essential in formulas.]* (2×3)

(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 (6)

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

(k) **A** WRITE: **$CaO + SiO_2 \rightarrow CaSiO_3$** FORMULAS: (3) BALANCING: (3)

or

B WRITE: **$O^{\bullet} + O_2 \rightarrow O_3$** *[Accept if $O_2 \rightarrow 2 O^{\bullet}$ 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 $E_2 - E_1 = hf (hv)$, [$E_2 - E_1$ *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 (h*f*, h*v*) /
emitting (giving out) light of **definite frequency (wavelength)** /
emitting light* according to $E_2 - E_1 = hf (hv)$, [$E_2 - E_1$ *symbols must be explained*]
[Accept "energy" for "light" if f(v) 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)

WHAT: **red (crimson)**   (3)

DESCRIBE: **salt on platinum (nichrome) probe (wire) / salt on soaked** wooden **splint (stick) / salt in solution** //

hold **in (over, against edge, at top) of flame*** / for solution **spray into flame*** (2×3)
[*Accept "Bunsen" for "flame."]

(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)** (2×3)
["position" and "momentum" are interchangeable.]

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**   (5)

(b) *(i)* GIVE: **A**   **pentane** //

B   **2-methylbutane**   (2 × 3)
[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: **C(CH$_3$)$_4$** // **(CH$_3$)$_3$C(CH$_3$)** // **(CH$_3$)$_2$C(CH$_3$)$_2$** //
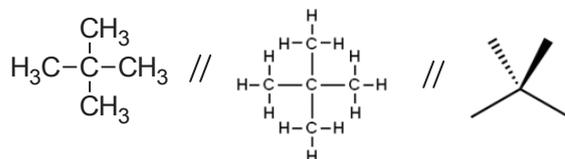
In the fully expanded formula the hydrogen atoms may be omitted. The diagram on the right requires some indication of non-planarity.

(3)

(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)
[PREDICT & JUSTIFY linked.]

(c) CALCULATE: **− 126.4** kJ   (15)

CaC$_2$			→	*Ca* + *2C*	*ΔH* =	**59.8** kJ	(3)
2H$_2$O			→	*2H$_2$* + *O$_2$*	*ΔH* =	**571.6** kJ	(3)
2C + *H$_2$*		→	*C$_2$H$_2$*	*ΔH* =	**227.4** kJ	(3)
Ca + *O$_2$* + *H$_2$*	→	*Ca(OH)$_2$*	*ΔH* = −	**985.2** kJ	(3)

CaC$_2$ + *2H$_2$O* → *C$_2$H$_2$* + *Ca(OH)$_2$*   *ΔH* = –126.4 kJ   (3)
Equations not required. [Award (3) for 126.4 (+126.4) unless it can be seen to merit more.]

$ΔH_{(reaction)}$ = $ΣΔH_{f(products)}$ − $ΣΔH_{f(reactants)}$
 = **227.4 (3) − 985.2 (3) − {− 59.8 (3) − 2 × 285.8 (3)}**
or = **227.4 (3) − 985.2 (3) + 59.8 (3) + 571.6 (3)**
 = **− 126.4** kJ (3)

(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 (*sp^2* 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)

If no marks have been awarded for part (d), 3 marks may be given for a structural formula of benzene with delocalised ring – atoms need not be explicitly shown.

QUESTION 7

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

                change in concentration

                           time   **(5)**

(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**   ANY ONE: **(6)**
[Do not accept "effective collisions."]

(c) SUGGEST: increased **pressure (concentration)** // increased* **temperature** *[accept "heat."]* // addition of a **catalyst** *[* Do not accept "low (decrease in) temperature".]* ANY TWO: **(2 × 3)**

      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 / **orients reactants correctly** / provides **active sites**
                                                         ANY TWO: **(2 × 3)**
                       [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   **(3 × 3)**
                      [* 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 /**
                      $\frac{\text{rate}}{\text{conc}} = k$ / $\frac{\text{conc}}{\text{rate}} = k$ /
                      plot of rate against concentration gives a straight line through the origin (0, 0)   **(3 × 3)**
                      [Marks obtainable from a correct sketch graph with axes labelled.]

(e) DRAW:
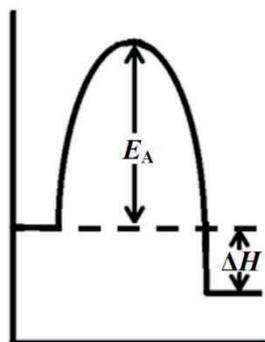
                                      exothermic reaction shown //

                                        (i)   **activation energy (E_A) //**

                                        (ii)   **heat of reaction (ΔH)**   **(3 × 3)**

                                      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** (3)

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 / **(Cl$^{\delta+}$–*Cl$^{\delta-}$)** // *[*Line essential]*

followed by **heterolytic fission of chlorine** molecule **(Cl₂)** / Cl₂ → **Cl$^+$ +*Cl$^-$** /
[* Bond must not be shown.]

addition (attraction, bonding) of Cl$^+$ (Cl$^{\delta+}$ – Cl$^{\delta-}$) to the double bond //
[Do not accept addition of Cl$^{\delta+}$; on a diagram Cl$^{\delta+}$ – Cl$^{\delta-}$ must be oriented correctly.]

forming a localised **carbonium ion* (carbocation*)** *[*Accept positive carbon (C$^+$).]*
(chloronium ion) /
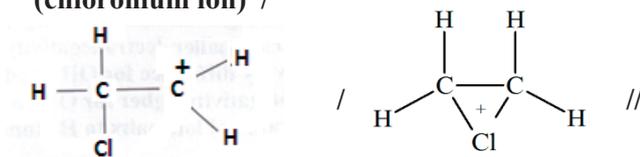
addition of chloride ion (Cl$^-$) to the intermediate (named intermediate) to give
1,2-dichloroethane ANY FOUR: (4 × 3)

[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

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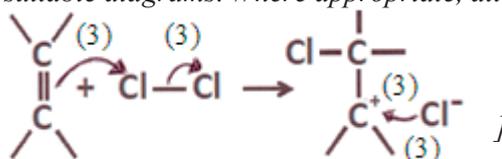
[If addition of HCl is described, award (3) for carbonium ion (not chloronium ion – but do not cancel). Award (3) for addition of chloride ion to carbonium ion.]

(d) DRAW: **CH₂ = CHCl** /
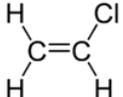
  (6)

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

(e) DRAW:
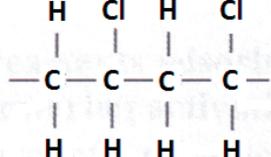
  / **– CH₂ – CHCl – CH₂ – CHCl –** (5)

[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) (2 × 3)
*[*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**".]* (3)

(c) WRITE: $\dfrac{[\mathbf{Fe(CNS)^{2+}}]}{[\mathbf{Fe^{3+}}][\mathbf{CNS^{-}}]}$ *[Accept FeCNS²⁺ for Fe(CNS)²⁺.]*

[Expression inverted (0).] (6)

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

	Fe^{3+}	+	CNS^-	$\leftrightharpoons$	$Fe(CNS)^{2+}$
Start (M)	1.0×10^{-3}		1.0×10^{-3}		0
Equil (M)	$\mathbf{8.9 \times 10^{-4}}$ (3)		**Ms the same** (3)		1.1×10^{-4} mol

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

$$= \mathbf{138.87 \ (138.9, 139)}$$ (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 (3)
[IS & JUSTIFY are linked.]

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   +   3Fe$_3$O$_4$ →   4Al$_2$O$_3$ +   9Fe**
   Al increased (oxidised) // 0 to +3 (3) / Fe decreased (reduced) // +2⅔ (2⅔)* to 0
   [Accept Fe$_3$O$_4$ for Fe.]   _[*Accept 3 or 2.]_   (2 × 3)
   [Change in oxidation numbers must be shown in some form.]

   IDENTIFY: **Al (aluminium)**   (3)

   _(ii)_   WHAT: **432** g   (9)

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

   WHAT: **816** g   (4)

   | 16 mol Al ≡ **8** mol Al$_2$O$_3$ (2)   × 102 = **816** g (2) |

   _Marks may be
   awarded to
   candidates for use
   of correct ratio
   of masses based
   on M$_r$._

(c) *(i)* 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* (6)

[* Do not accept "atom" for "nucleus".]

(ii) GIVE: *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) GIVE: **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%** (7)

[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**   (4 + 3)

_(i)_ DEDUCE: _B_ is **helium //** _P_ is **sulfur (sulphur)**   (2 × 3)

WHAT: **900**   (3)

_(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)**   (3)
["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** / $2p_x{}^2 2p_y{}^1 2p_z{}^1$ or $2p^4$ or $2p$ ↓↑ ↓ ↓ / **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 / $2p_x{}^1 2p_y{}^1 2p_z{}^1$ or $2p^3$ or $2p$ ↓ ↓ ↓ /
half-full 2p-sublevel /   (2 × 3)

_(b)_ DEFINE: _(i)_ _Arrhenius_: dissociates to produce **hydroxyl (hydroxide) ions (OH^-)
in aqueous solution (water) //**

_(ii)_ _Brønsted-Lowry_: **proton (hydrogen ion, H^+) acceptor**   (4 + 3)

GIVE: _(i)_ $H_2PO_4{}^-$ // _(ii)_ $PO_4{}^{3-}$ (2 × 3)

CALCULATE: **11.28 (11.3)**   (12)

7 g of NH_4OH = 7 ÷ 35 = 0.2 mol ⇒ **0.2 M NH_4OH**	(3)

$[OH^-] = \sqrt{1.8 \times 10^{-5} \times 0.2}$ / 1.9×10^{-3}	(3)
$pOH = -\log 1.9 \times 10^{-3} = $ **2.72 (2.7)**	(3)
$pH = 14 - 2.72\ (2.7) = $ **11.28 (11.3)**	(3)

$[OH^-] = \sqrt{1.8 \times 10^{-5} \times 0.2}$ / 1.9×10^{-3}	(3)
$[H^+] = \dfrac{1 \times 10^{-14}}{\sqrt{1.8 \times 10^{-5} \times 0.2}}$ / $\dfrac{1 \times 10^{-14}}{1.9 \times 10^{-3}}$ / 5.3×10^{-12}	(3)
$pH = -\log 5.3 \times 10^{-12} = $ **11.28 (11.3)**	(3)

(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)** (4)

[Do not accept "chemical change produced by electrical energy (current)".]

(ii) WHY: so that **ions** are **free to move** (3)

(iii) SUGGEST: **platinum (Pt) / carbon (C, graphite)** (3)

(iv) WRITE: $Pb^{2+} + 2e^- \rightarrow Pb$ (3)

$2Br^- \rightarrow Br_2 + 2e^- / 2Br^- - 2e^- \rightarrow Br_2 /$
$Br^- \rightarrow \frac{1}{2}Br_2 + e^- / Br^- - e^- \rightarrow \frac{1}{2}Br_2$ 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** (2 × 3)

(ii) EXPLAIN: **fixed** costs **//** must be **paid regardless of** level of **production** (2 × 3)

[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)** (3)

(iv) GIVE: *batch*: **versatile (usable for diff. processes / usable to make diff. products) / suit seasonal products / usable for trial runs / small quantities** can be **economic**ally 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** (2 × 3)

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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