N13/4/CHEMI/SP2/ENG/TZ0/XX/M

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MARKSCHEME

November 2013

CHEMISTRY

Standard Level

Paper 2

12 pages

Subject Details: Chemistry SL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A **[30 marks]** and **ONE** question in Section B **[20 marks]**. Maximum total = **[50 marks]**.

1. A markscheme often has more marking points than the total allows. This is intentional.

2. Each marking point has a separate line and the end is shown by means of a semicolon (;).

3. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.

4. Words in brackets ( ) in the markscheme are not necessary to gain the mark.

5. Words that are underlined are essential for the mark.

6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

7. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect).

8. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

9. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.

10. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.

11. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the markscheme. Similarly if the formula is specifically asked for, unless directed otherwise in the markscheme, do not award a mark for a correct name.

12. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the markscheme.

13. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the markscheme.

SECTION A

1. (a) $\left(\frac{0.0200}{166.00} = \right) 0.000120 / 1.20 \times 10^{-4}\,(\text{mol})$; ***[1]***

Accept 1.21×10^{-4}.

(b) $(0.0050 \times 2.00 =) 0.010\,(\text{mol}) / 1.0 \times 10^{-2}$; ***[1]***

(c) KI/I^-/potassium iodide/iodide (ion) (rapidly) reformed (in second stage of reaction); ***[1]***

(d) amount (in mol) of H_2O_2/hydrogen peroxide >> amount (in mol) $Na_2S_2O_3$/$S_2O_3^{2-}$ /sodium thiosulfate/ thiosulfate (ion);
Accept amount (in mol) of H_2O_2/hydrogen peroxide >> amount (in mol) KI/I^- /potassium iodide/iodide (ion).
Accept "[H_2O_2]/hydrogen peroxide is in (large) excess/high concentration".

(at end of reaction) [H_2O_2] is only slightly decreased/virtually unchanged; ***[2]***

(e) all $Na_2S_2O_3$/sodium thiosulfate/$S_2O_3^{2-}$/thiosulfate consumed/used up;
Accept "iodine no longer converted to iodide".

(free) iodine is formed / iodine reacts with starch / forms iodine-starch complex; ***[2]***

(f) *Random:* synchronizing mixing and starting timing / (reaction) time / uncertainty of concentrations of solutions / temperature of solutions/room temperature;;

OR

Systematic: liquid remaining in measuring cylinders / not all solid KI transferred / precision uncertainty of stopwatch / ability of human eye to detect colour change / parallax error;; ***[2]***
Accept concentration of stock solution and human reaction time as systematic error.
Award M1 for correctly identifying a source of error and M2 for classifying it.
Accept other valid sources of error.
*Do **not** accept "student making mistakes" / OWTTE.*

(g) $(5 \times 0.1) = (\pm) 0.5\,(\text{cm}^3)$; ***[1]***

(h) total volume $= 0.100\,(\text{dm}^3) / 100\,(\text{cm}^3)$;

(change in concentration $= \frac{1.00 \times 10^{-4}}{0.100} =) 1.00 \times 10^{-3}\,(\text{mol dm}^{-3})$;

$\left(\text{rate} = \frac{1.00 \times 10^{-3}}{45} = \right) 2.2 \times 10^{-5}$;

*Award **[3]** for the correct final answer.*

$\text{mol dm}^{-3}\ \text{s}^{-1}$; ***[4]***

(i) fewer particles (per unit volume);
lower collision rate/collision frequency / less frequent collisions; ***[2]***
*Do **not** accept "less collisions".*

(j) acting as a catalyst / black powder reacts with thiosulfate ions / solid dissolves to give blue-black solution;
Accept any other valid suggestion which will make colour change more rapid.

For catalyst: amount/mass of black powder remains constant / no new/different products formed / activation energy decreased;
For other suggestions: any appropriate way to test the hypothesis; ***[2 max]***
*Award **[1]** for valid hypothesis, **[1]** for appropriate method of testing the stated hypothesis.*

(k) particles have greater (average) kinetic energy;
Do not accept energy instead of kinetic energy.

more frequent collisions/collision frequency/number of collisions in a given time increases;
*Do **not** accept "more collisions" unless "less collisions" penalized in (i).*

greater proportion of particles have energy ≥ activation energy; ***[2 max]***
Accept "particles have sufficient energy for collisions to be successful".

2. (a) C_2H_5Cl **and** HCl; ***[1]***

(b) (free) radical substitution / S_R; ***[1]***
*Accept homolytic fission / initiation **and** propagation (and termination).*

(c) ethyl radicals/$C_2H_5\bullet$ produced;
Accept C_2H_5.

combine to form butane/C_4H_{10}; ***[2]***
*Award **[2]** for the terminating step equation* $C_2H_5\bullet + C_2H_5\bullet \rightarrow C_4H_{10}$.

3. (a) (i) Ca^{2+} **and** NO_3^-;
electrostatic (attraction); ***[2]***
Do not accept ionic.

(ii) nitrogen/N **and** oxygen/O; ***[1]***
Do not accept nitrate/NO_3^-.
Accept atoms in nitrate/NO_3^-.

(b) (i) produced by high temperature combustion; ***[1]***
Accept combustion/jet/car engines / car exhaust/emissions / lightning / action of bacteria/microorganisms.
Do not accept combustion/burning, cars, planes, jets, factories, power plants etc.

(ii) nitric acid/HNO_3 / nitrous acid/nitric(III) acid/HNO_2; ***[1]***
Accept "forms acidic solutions / acid rain".

(iii) acid deposition/rain / respiratory problems / corrosion problems / decomposition of ozone layer / photochemical smog / acidification/pollution of lakes / damage to plants/ trees; ***[1]***
Accept "acid rain" in either part (ii) or part (iii) but not both.
Do not accept air pollution.

SECTION B

4. (a) $\underline{(l)}\ N(NO_2)_3(g) + \underline{2}\ CH_3OH(l) \rightarrow \underline{2}\ N_2(g) + \underline{2}\ CO_2(g) + \underline{4}\ H_2O(l)$; ***[1]***

(b) products from the reaction are non-toxic/normal components of the atmosphere / nitrogen is a product rather than oxides of nitrogen; ***[1]***
Accept "no chlorine produced".
*Do **not** accept "non-polluting".*

(c) *bonds broken:* $(6\times305)+(3\times158)=1830+474=2304\,(kJ\,mol^{-1})$;
bonds made: $(2\times945)+(3\times498)=1890+1494=3384\,(kJ\,mol^{-1})$;
enthalpy change: $2304-3384=-1080\,(kJ\,mol^{-1})$; ***[3]***
*Award **[3]** for correct final answer.*
*Award **[2 max]** for $+1080\,(kJ\,mol^{-1})$.*

Accept –234 kJ mol^{-1} which arise from students assuming that 305 kJ mol^{-1} refers to the strength of a single N–O bond. Students may then take N=O from the data book value (587 kJ mol^{-1}).
bonds broken: $(3\times305)+(3\times587)+(3\times158)=915+1761+474=3150\,(kJ\,mol^{-1})$
bonds made: $(2\times945)+(3\times498)=1890+1494=3384\,(kJ\,mol^{-1})$
enthalpy change: $3150-3384=-234\,(kJ\,mol^{-1})$.

*Award **[2 max]** for correct calculation of the enthalpy change of reaction for the equation in part (a), which gives –2160 (kJ mol^{-1}).*
*Award **[1]** if the final answer is not –2160 but the candidate has correctly calculated the bonds broken in trinitramide as 2304 (kJ mol^{-1}).*

(d) (N–N bond in) trinitramide is longer/nitrogen (gas) is shorter / 0.145 nm in trinitramide versus 0.110 nm in nitrogen;
trinitramide has single (N–N) bond **and** nitrogen (gas) has triple bond; ***[2]***

(e) $106^\circ - 108^\circ$;
Accept $< 109^\circ$.

*Any two for **[2 max]**.*
4 (negative) charge centres/electron pairs/electron domains around central nitrogen;
<u>central</u> nitrogen has a lone/non-bonding pair;
lone/non-bonding pairs repel more than bonding pairs;
molecule will be (trigonal/triangular) pyramidal;
(negative) charge centres/electron pairs/electron domains will be tetrahedrally arranged/orientated/ have tetrahedral geometry; ***[3 max]***
Do not apply ECF.

(f) polar;
net dipole moment present in molecule / unsymmetrical distribution of charge / polar bonds do not cancel out / centre of negatively charged oxygen atoms does not coincide with positively charged nitrogen atom; ***[2]***
Marks may also be awarded for a suitably presented diagram showing net dipole moment.
Do not accept "unsymmetrical molecule".
For polarity, apply ECF from part (e).

(g) (i) burn/combust a (known) mass/volume/quantity/amount of methanol (in a spirit burner) / weigh methanol/spirit burner before and after combustion;
use flame to heat a (known) mass/volume/quantity/amount of water;
measure the increase/rise/change in temperature (of the water); ***[3]***

(ii) calculate the heat gained by the water / calculate the heat evolved by the burning methanol / substitute in $q = mc\Delta T$;
calculate the amount/moles of methanol / divide the mass of methanol by its molar mass;
divide the heat gained by the water by the amount/moles of methanol; ***[3]***

(iii) result would be less exothermic/less negative;
Accept "less/smaller/lower".

heat loss / incomplete combustion; ***[2]***
Accept methanol is volatile/evaporates / beaker/material of calorimeter absorbs heat.

5. (a) (i)

Initial oxidation number		Final oxidation number	Oxidized / reduced
IV/+4	**and**	III/+3;	reduced;

[2]

+ sign must be present. Do not award mark for incorrect notation 4, 4+, 3, 3+ etc.
Do not award M2 if inconsistent with M1.

(ii) increases / makes it stronger;
(more H^+ would) drive/shift equilibrium to the right/towards products (accepting more electrons); ***[2]***

(b) (i) Cd^{2+}; ***[1]***
Do not allow incorrect notation such as Cd, Cd(II), or Cd^{+2}.

(ii) $2Ti(s) + 3Cd^{2+}(aq) \rightarrow 2Ti^{3+}(aq) + 3Cd(s)$; ***[1]***
Ignore state symbols.
Allow ECF from (b)(i) for a correct equation.

(iii) Cd^{2+}; ***[1]***
Charge must be given.
Do not allow incorrect notation such as Cd, Cd(II), or Cd^{+2} but penalize only once in b(i) and b(iii) .
Allow ECF, if Eu^{2+} is written both in part (i) and part (iii).

(iv) salt bridge;
Accept specific examples of salt bridges, such as filter paper dipped in aqueous KNO_3.

allows the movement of ions (between the two solutions) / completes the circuit / maintains electrical neutrality; ***[2]***
Accept movement of charges/negative ions/positive ions.

(c) (i) donates H^+/protons; ***[1]***

(ii) strong acid completely/100%/fully dissociated/ionized **and** weak acid partially/slightly dissociated/ionized; ***[1]***

(iii) not a good choice / poor choice;
requires same volume of the base / the amount/volume to react/for neutralization does not depend on the acid strength; ***[2]***

(iv) sulfuric acid is diprotic/dibasic/liberates two protons/H^+; ***[1]***
Accept "reacts with 2 moles of alkali/base".

(v) *Strong acid*: hydrochloric acid/HCl / nitric acid/HNO_3;
Weak acid: ethanoic acid/CH_3COOH; ***[2]***
Allow acetic acid for weak acid.
*Accept any other strong/weak **monobasic** acids as appropriate.*
*Do **not** accept non-monobasic acids, such as phosphoric acid and carbonic acid.*

(vi) weak;
strong 0.100 mol dm^{-3} acid has a pH of 1/lower than that observed; ***[2]***
Accept "pH value of 3.7 means that it produces only $10^{-3.7}/2.0\times10^{-4}$ $[H^+]$ in water".

(vii) measure the rate of reaction with reactive metal/(metal) carbonate/metal oxide;
strong acid would react faster/more vigorously / weak acid would react slower/less vigorously;
Accept specific substances, such as Mg and $CaCO_3$, which react with acids.

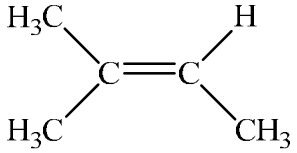
OR

measure conductivity;
higher for strong acid / lower for weak acid;

OR

measure heat/enthalpy of neutralization;
greater for strong acid / lower for weak acid; ***[2]***

Do not accept pH/universal indicator paper.

6. (a)  / $(CH_3)_2C{=}CH{-}CH_3$; ***[1]***

Accept condensed formula such as $(CH_3)_2CCHCH_3$.

(b) water/H_2O;
Accept steam.

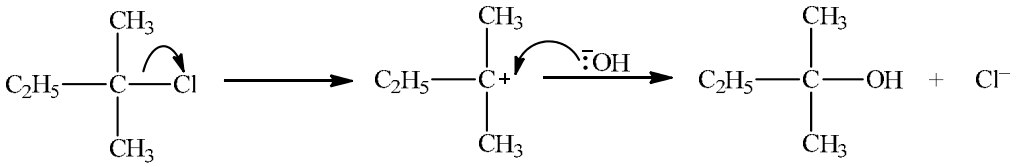
(concentrated) sulfuric acid/H_2SO_4 (catalyst); ***[2]***
Accept phosphoric acid/H_3PO_4.
*Award **[2]** for HBr and NaOH, (2 stage process via the halogenoalkane).*

(c) not react;
tertiary alcohol (not easily oxidized); ***[2]***

(d) 2-methylbutan-2-ol has hydroxyl/OH group;
Do not accept "hydroxide group".
Allow 2-methylbutan-2-ol is an alcohol.

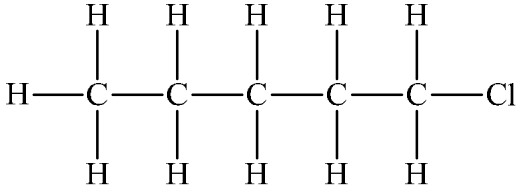
2-methylbutan-2-ol can form H-bonds (to water) / 2-methylbut-2-ene cannot form H-bonds (to water); ***[2]***

(e) (i) $S_N(1)$ / (unimolecular) nucleophillic substitution; ***[1]***

(ii) 

curly arrow showing Cl^- leaving;
representation of tertiary carbocation;
curly arrow going from lone pair/negative charge on O in HO^- to C^+;
Do not allow arrow originating on H in HO^-.

formation of organic product $CH_3CH_2C(CH_3)_2OH$ **and** Cl^-/NaCl (somewhere in mechanism); ***[4]***
*Award **[3 max]** if a candidate gives a fully correct S_N2 mechanism.*

(iii)  ; ***[1]***

Accept any other isomeric primary or secondary chloroalkane.
Accept condensed structural formula.

(f) (i) chlorine can be ^{35}Cl/Cl–35 or ^{37}Cl/Cl–37; ***[1]***
Accept "chlorine can exist as two isotopes".
Answer must refer to chlorine rather than isotopes in general.

(ii) same rate as (isotopes have) same chemical properties; ***[1]***
Accept different rate if reference is made to molecules having different speeds/collision rate.

(g) vaporization to convert sample to gaseous state;
(neutral) particles converted to ions / (neutral) particles ionized / ionization;
accelerated (ions) through an electric field/(oppositely) charged plates/potential difference;
(ions) bent/deflected by a magnetic field;
light particles bent/deflected more than heavy ones / heavy particles bent/deflected less than light ones / mass/charge ratio;
detection by ions hitting the counter/generating an electric signal / *OWTTE*; ***[5 max]***
Any or all marks can be gained by a suitably labelled diagram.
*Award **[2 max]** for just stating all five terms: vaporization, ionization, acceleration, deflection and detection.*
*Award **[1 max]** if three or four of these just stated.*