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MARKSCHEME

May 2010

CHEMISTRY

Standard Level

Paper 2

15 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. Do not award more than the maximum marks allowed for part of a question.

2. Each marking point has a separate line and the end is signified 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 writing ***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. Indicate this with **ECF** (error carried forward).

10. Only consider units at the end of a calculation. Unless directed otherwise in the markscheme, unit errors should only be penalized once in the paper. Indicate this by writing **–1(U)** at the first point it occurs and **U** on the cover page.

11. Significant digits should only be considered in the final answer. Deduct **1 mark in the paper** for an **error of 2 or more digits** unless directed otherwise in the markscheme.

e.g. if the answer is 1.63:

2	*reject*
1.6	accept
1.63	accept
1.631	accept
1.6314	*reject*

Indicate the mark deduction by writing **–1(SD)** at the first point it occurs and **SD** on the cover sheet.

12. If a question specifically asks for the name of a substance, do not award a mark for a correct formula, similarly, if the formula is specifically asked for, do not award a mark for a correct name.

13. 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.

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

SECTION A

1. (a) $n(\text{HCl})(= 0.200\ \text{mol dm}^{-3} \times 0.02720\ \text{dm}^3) = 0.00544 / 5.44 \times 10^{-3}(\text{mol})$; ***[1]***

(b) $n(\text{HCl})$ excess $(= 0.100\ \text{mol dm}^{-3} \times 0.02380\ \text{dm}^3) = 0.00238 / 2.38 \times 10^{-3}(\text{mol})$; ***[1]***

Penalize not dividing by 1000 once only in (a) and (b).

(c) $n(\text{HCl})$ reacted $(= 0.00544 - 0.00238) = 0.00306 / 3.06 \times 10^{-3}(\text{mol})$; ***[1]***

(d) $2\text{HCl(aq)} + \text{CaCO}_3\text{(s)} \rightarrow \text{CaCl}_2\text{(aq)} + \text{H}_2\text{O(l)} + \text{CO}_2\text{(g)}$ /
$2\text{H}^+\text{(aq)} + \text{CaCO}_3\text{(s)} \rightarrow \text{Ca}^{2+}\text{(aq)} + \text{H}_2\text{O(l)} + \text{CO}_2\text{(g)}$; ***[2]***

*Award **[1]** for correct reactants and products.*
*Award **[1]** if this equation correctly balanced.*
*Award **[1 max]** for the following equations:*
$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2CO_3(aq)$
$2H^+(aq) + CaCO_3(s) \rightarrow Ca^{2+}(aq) + H_2CO_3(aq)$
Ignore state symbols.

(e) $n(\text{CaCO}_3) = (\frac{1}{2}\, n(\text{HCl})) = \frac{1}{2} \times 0.00306$;
$= 0.00153 / 1.53 \times 10^{-3}\ (\text{mol})$; ***[2]***

*Award **[2]** for correct final answer.*

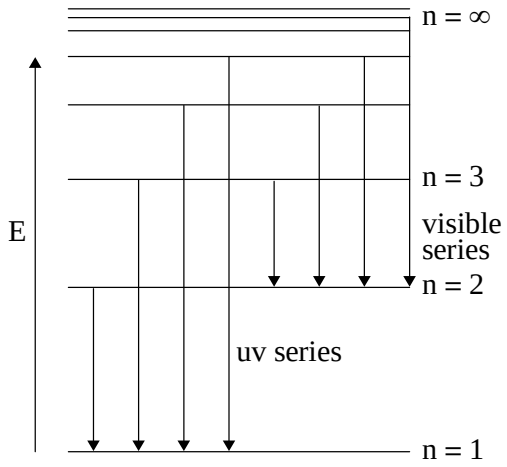
(f) $M_r(\text{CaCO}_3)\ (= 40.08 + 12.01 + 3 \times 16.00) = 100.09 / 100.1 /\ M = 100.09 / 100.1\ (\text{g mol}^{-1})$;
Accept 100.

$m(\text{CaCO}_3)\ (= nM) = 0.00153\ (\text{mol}) \times 100.09\ (\text{g mol}^{-1}) = 0.153(\text{g})$;
$\%\ \text{CaCO}_3 \left(= \dfrac{0.153}{0.188} \times 100 \right) = 81.4\ \% / 81.5\ \%$; ***[3]***

Accept answers in the range 79.8 to 81.5 %.
*Award **[3]** for correct final answer.*

(g) only CaCO_3 reacts with acid / impurities are inert/non-basic / impurities do not react with the acid / nothing else in the eggshell reacts with acid / no other carbonates; ***[1]***
Do not accept "all calcium carbonate reacts with acid".

2.



showing *y*-axis labelled as energy/E / labelling at least two energy levels;
showing a minimum of four energy levels/lines with convergence;
showing jumps to $n = 1$ for ultraviolet series;
showing jumps to $n = 2$ for visible light series; ***[4]***
Must show at least two vertical lines per series to score third and fourth mark but penalize once only.
For third and fourth marks if transition not shown from higher to lower energy level penalize only once.

3. (a) as (cat)ion becomes more positive / Na^+, Mg^{2+}, Al^{3+} / size/radius decreases / charge density increases;
Do not allow increasing number of protons or increasing nuclear charge.

attraction for mobile/valence/delocalized/sea of electrons increases; ***[2]***
Do not accept "cloud of electrons".

(b) larger molecule / higher M_r/M / greater number of electrons;
Do not accept "larger/higher/greater mass".

greater van der Waals'/dispersion/London forces; ***[2]***

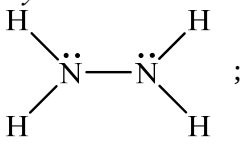
(c) *Si:* giant/network/macromolecular/3-D covalent bonding;
No mark for strong bonding without reference to covalent and network.
No mark for molecular.

Ar: (simple) atomic / (only weak) van der Waals'/dispersion/London forces; ***[2]***
No mark for (simple) molecular.

4. (a) $N_2H_4(g) + 2F_2(g) \rightarrow N_2(g) + 4HF(g)$

*Award **[1]** for reactants and products.*
*Award **[1]** of this equation is correctly balanced.* ***[2]***
Ignore state symbols.

(b) *Hydrazine:*



;

Nitrogen:

; ***[2]***

Accept lines, dots and crosses to show electron pairs.
Penalize missing lone pairs once only.

(c) $\sum \text{BE (bonds broken)} = (4 \times 391) + 158 + 2(158) / 2038\,(\text{kJ})$;

$\sum \text{BE (bonds formed)} = (945) + 4(568) / 3217\,(\text{kJ})$;

$\Delta H^{\ominus} = 2038 - 3217 = -1179\,(\text{kJ})$; ***[3]***

*Award **[3]** for correct final answer.*
*Award **[2]** for (+)1179 (kJ).*

(d) (N_2H_4 / F_2) better rocket fuel;
ECF: answer must be consistent with equation in (a) and ΔH in (c).

5 vol/mol (g) > 3 vol/mol (g) / more moles/greater amount of gas produced;
$\Delta H^{\ominus}(N_2H_4 / F_2) > \Delta H^{\ominus}(N_2H_4 / O_2)$ (per mole) / (N_2H_4 / F_2) reaction more exothermic; ***[2 max]***

SECTION B

5. (a) (i) atomic number / Z; ***[1]***
Accept nuclear charge / number of protons.

(ii) *Across period 3:*
increasing number of protons / atomic number / Z / nuclear charge;
(atomic) radius/size decreases / same shell/energy level / similar shielding/screening (from inner electrons);
No mark for shielding/screening or shielding/screening increases.

Noble gases:
do not form bonds (easily) / have a full/stable octet/shell/energy level / cannot attract more electrons; ***[3]***
Do not accept "inert" or "unreactive" without reference to limited ability/inability to form bonds or attract electrons.

(b) (i) energy/enthalpy change/required/needed to remove/knock out an electron (to form +1/uni-positive/ M^{+1} ion);
in the gaseous state; ***[2]***
*Award **[1]** for* $M(g) \rightarrow M^{+}(g) + e^{-}$.
*Award **[2]** for* $M(g) \rightarrow M^{+}(g) + e^{-}$ *with reference to energy/enthalpy change.*

(ii) increasing number of protons/atomic number/Z/nuclear charge;
atomic radii/size decreases / same shell/energy level / similar shielding/ screening (from inner electrons); ***[2]***
No mark for shielding/screening or shielding/screening increases.

(iii) *Na:* delocalized electrons / mobile sea of electrons / sea of electrons free to move;
No mark for just "mobile electrons".

P: atoms covalently bonded / no free/mobile/delocalized electrons; ***[2]***

(c) (i) $Pb: 0, PbO_2: +4, PbSO_4: +2$; ***[1]***
Need sign for mark.
Do not accept notations such as 4+, 2+ or IV, II.

(ii) *Negative/–/anode*

$Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^- / Pb(s) \rightarrow Pb^{2+}(aq) + 2e^-$;

Positive/+/cathode

$PbO_2(s) + 4H^+(aq) + SO_4^{2-}(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$ /

$PbO_2(s) + 4H^+(aq) + 2e^- \rightarrow Pb^{2+}(aq) + 2H_2O(l)$ /

$PbO_2(s) + H_2SO_4(aq) + 2H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$;

Accept $Pb^{4+} + 2e^- \rightarrow Pb^{2+}$.

Ignore state symbols.

Allow e instead of e^-.

oxidizing agent is PbO_2/lead(IV) oxide/lead dioxide **and** reducing agent is Pb/lead;

from negative/–/anode/Pb to positive/+/cathode/PbO_2 (through the external circuit/wire); ***[4]***

(iii) $Pb(s) + Cu^{2+}(aq) \rightarrow Pb^{2+}(aq) + Cu(s)$

$Pb(s) + 2Ag^+(aq) \rightarrow Pb^{2+}(aq) + 2Ag(s)$

$Cu(s) + 2Ag^+(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$

Award ***[2]*** *for three correct, award* ***[1]*** *for any two correct, one correct scores no mark.*

Ignore state symbols.

Penalize unbalanced equations once only.

Pb is a stronger reducing agent than Cu and/or Ag / Pb most reactive as it can reduce/displace both Cu^{2+} and Ag^+;

Cu is a stronger reducing agent than Ag but not Pb / Cu in the middle (of the three) as it can reduce/displace Ag^+ but not Pb^{2+};

Accept converse argument.

D*ecreasing order:* Pb, Cu, Ag / Pb > Cu > Ag; ***[5]***

Do not accept: Pb^{2+}, Cu^{2+}, Ag^+.

6. (a) (i) $K_c = \frac{[H^+][OH^-]}{[H_2O]}$ / $K_c = \frac{[H_3O^+][OH^-]}{[H_2O]}$ / $K_w = [H^+][OH^-]$ / $K_w = [H_3O^+][OH^-]$; ***[1]***

Do not award mark if [ ] are omitted or other brackets are used.
Expression must be consistent with K_c/K_w.

(ii) $[H^+]$ increases, $[OH^-]$ decreases but still some present (K_w/K_c constant) / $[OH^-]$ cannot go to zero as equilibrium present / $[OH^-] = \frac{K_w}{[H^+]} / \frac{K_c[H_2O]}{[H^+]}$, thus $[OH^-]$ cannot be zero / *OWTTE*; ***[1]***

Accept equilibrium present.

(iii) (changing T disturbs equilibrium) forward reaction favoured / equilibrium shifts to the right;
to use up (some of the) heat supplied;
(K_w/K_c) increases (as both $[H^+]$ and $[OH^-]$ increase); ***[3]***

(iv) $pH = 2, [H^+] = 0.01\,mol\,dm^{-3}$ **and** $pH = 6, [H^+] = 10^{-6}\,mol\,dm^{-3}$ / $[H^+] = 10^{-pH}$;
$[H^+]$ decreased/changed by $10000/10^{-4}$; ***[2]***

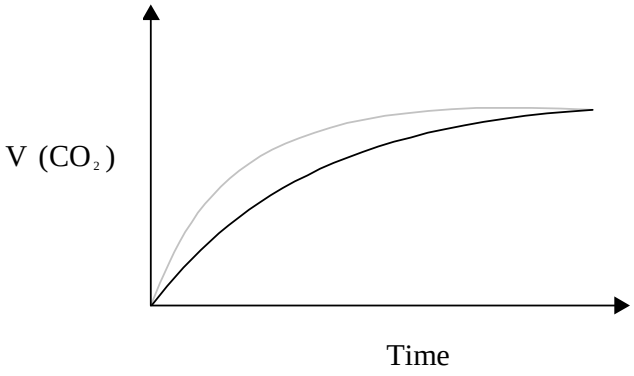
*Award **[2]** for correct final answer.*

(b) $CO_2(g)$/gas escapes / (gas) pressure / $[CO_2]$ (above liquid) decreases / bubbles (of CO_2 gas) form in the liquid;
equilibrium shifts to the right (to replace the lost CO_2 gas) ; ***[2]***

(c) (i) rate = increase in $\frac{\text{volume}}{\text{time}}$ = slope of graph;
initially/to begin with steeper slope / fastest rate / volume of gas/ CO_2 produced faster/quickly as concentration of HCl highest / *OWTTE*;
as reaction progresses/with time, less steep slope / volume of gas production slows / rate decreases due to less frequent collisions as concentration (of HCl) decreases / *OWTTE*;
curve flattens/becomes horizontal when HCl used up/consumed (as there are no more H^+ ions to collide with the $CaCO_3$ particles); ***[3 max]***

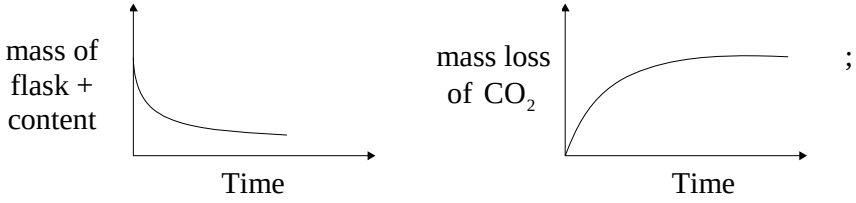
Each mark requires explanation.

(ii)



less steep curve;
same maximum volume at later time;
half/lower H^+ /acid concentration less frequent collisions/slower rate;
same amount of HCl, same volume CO_2 produced; ***[4]***

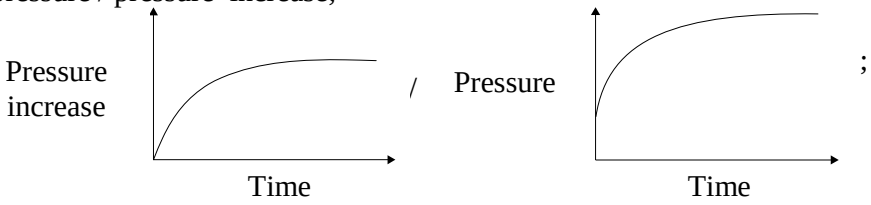
(iii) mass loss/of CO_2 / mass of flask + content;



;

OR

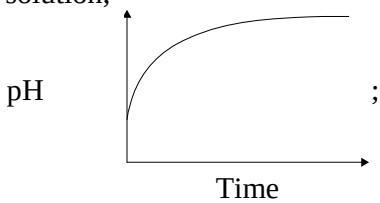
pressure / pressure increase;



;

OR

pH of solution;



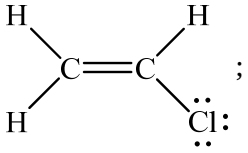
; ***[2]***

Do not penalize for missing x-axis label or for missing units on y-axis.
Accept if line meets time axis.

(iv) minimum energy (of colliding particles) for a reaction to occur / *OWTTE*;
lower E_a / greater surface area/contact between $CaCO_3$ and HCl / higher HCl concentration / (sufficient) particles/molecules have activation energy; ***[2]***

7. (a) (i) colour change from yellow/orange/rust colour/red/brown to colourless; ***[1]***
No mark for change to clear, or for decolourized with no reference to original colour.

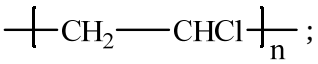
(ii) *Chloroethene:*



;

No mark if the lone pairs missing on Cl.
Accept lines, dots or crosses for e^- pairs.

Poly(chloroethene):

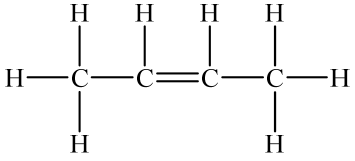


; ***[2]***

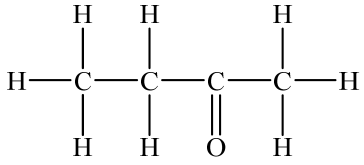
n and square brackets are not required.
Continuation bonds must be shown.

(iii) (hydration of ethene for the manufacture of) ethanol/ $C_2H_4 + H_2O \rightarrow C_2H_5OH$;
(synthesis of) CH_3COOH /ethanoic/acetic acid;
(synthesis of) ethylene glycol/1,2-ethanediol/ethane-1,2-diol;
(synthesis of) drugs/pesticides;
(hydrogenation of unsaturated oils in the manufacture of) margarine; ***[2 max]***
Accept other commercial applications.

(b) (i)



/ $CH_3CH{=}CHCH_3$;



/ $CH_3CH_2COCH_3$; ***[2]***

Penalize missing H atoms once only.

(ii) $CH_3CH{=}CHCH_3 + H_2O \rightarrow CH_3CH(OH)CH_2CH_3$;
concentrated sulphuric acid/ H_2SO_4 **and** heat/stream / phosphoric acid/H_3PO_4 (catalyst) **and** heat/steam;
$3CH_3CH(OH)CH_2CH_3 + Cr_2O_7^{2-} + 8H^+ \rightarrow 3CH_3COCH_2CH_3 + 2Cr^{3+} + 7H_2O$;
Accept $CH_3CH(OH)CH_2CH_3 + [O] \rightarrow CH_3COCH_2CH_3 + H_2O$.
Accept C_2H_5 as CH_2CH_3.

dichromate(VI) (ion)/$Cr_2O_7^{2-}$ **and** acidic/H^+;
Accept MnO_4^- in place of $Cr_2O_7^{2-}$ in third and fourth marks.

heat/reflux; ***[5]***

(c) (i) $CH_3CH_2CH_2OH$, propan-1-ol/1-propanol;
$CH_3CH(OH)CH_3$, propan-2-ol/2-propanol;
Need both formula and name for mark.
Accept either condensed or full structural formulas.

$CH_3CH_2CH_2OH$: primary **and** *$CH_3CH(OH)CH_3$:* secondary; ***[3]***

(ii) CH_3CH_2CHO;
CH_3CH_2COOH;
CH_3COCH_3;
Accept either condensed or full structural formulas.

from propan-1-ol: CH_3CH_2CHO (propanal) obtained by distillation (as product is formed);
propan-1-ol gives CH_3CH_2COOH (propanoic acid) by (heating under) reflux;
*Award **[1]** if CH_3CH_2CHO and CH_3CH_2COOH identified but conditions not given/incorrect.*

propan-2-ol gives CH_3COCH_3 by heat / reflux; ***[5 max]***