M08/4/CHEMI/HP2/ENG/TZ1/XX/M+

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MARKSCHEME

May 2008

CHEMISTRY

Higher Level

Paper 2

16 pages

Subject Details: Chemistry HL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A **[40 marks]** and **TWO** questions in Section B **[2 × 25 marks]**. Maximum total = **[90 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 mark scheme, 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 page.

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) 1.17/233.4;
5.01×10^{-3} / 5.02×10^{-3} (mol); ***[2]***

(b) 5.01×10^{-3} / 5.02×10^{-3} (mol); ***[1]***

(c) 2.50×10^{-3} / 2.51×10^{-3} (mol); ***[1]***

(d) (i) Iron $55.85\times2.50\times10^{-3}=0.140\,\text{g}$;
(ii) Ammonium $18.05\times5.01\times10^{-3}=0.0904\,\text{g}$;
(iii) Sulfate $96.06\times5.01\times10^{-3}=0.481\,\text{g}$; ***[3]***

(e) $0.982\,\text{g}-0.711\,\text{g}=0.271\,\text{g}\,H_2O$;
$\frac{0.271}{18.02}=1.50\times10^{-2}\,(\text{mol})$; ***[2]***

(f) $\frac{0.711}{284.07}=2.50\times10^{-3}\,(\text{mol})$;

$\frac{1.50\times10^{-2}}{2.50\times10^{-3}}=6\,(\text{mol})$; ***[2]***
*Award **[2]** for the correct final answer.*
Allow ECF throughout question one.

2. (a) (i) $^{203}_{81}T1^{+}$ **and** $^{205}_{81}T1^{+}$; ***[1]***
Both ions must have positive charge.

(ii) $^{203}_{81}T1^{+}$; ***[1]***
Do not penalize missing positive charge.

(iii) more;
deflection depends on their mass to charge ratio/$\frac{m}{z}$ / *OWTTE*; ***[2]***

(b) $10x+(1-x)11=10.81$;
19 %;
81 %; ***[2 max]***
*Award **[2]** for two correct final answers.*

3. (a) $CH_3CH(OH)COOH + H_2O \rightleftharpoons CH_3CH(OH)COO^- + H_3O^+$ ***[2]***

*Award **[1]** for correct reactants and products and **[1]** for $\rightleftharpoons$ sign.*
Accept $CH_3CH(OH)COOH \rightleftharpoons CH_3CH(OH)COO^- + H^+$.

(b) $K_a = \frac{[CH_3CH(OH)COO^-][H_3O^+]}{[CH_3CH(OH)COOH]}$; ***[1]***

Accept $[H^+]$ instead of $[H_3O^+]$.

(c) $1.40 \times 10^{-4} = \frac{[H^+]^2}{0.250}$;
$[H^+] = 5.92 \times 10^{-3} (\text{mol dm}^{-3})$; ***[2]***
*Award **[2]** for the correct final answer.*

(d) $1.40 \times 10^{-4} \times \frac{0.250}{0.125}$;
$[H^+] = 2.80 \times 10^{-4} (\text{mol dm}^{-3})$; ***[2]***
*Award **[2]** for the correct final answer.*

(e) equilibrium shifts to the left/side of the reactants;
increase in the concentration of lactate ions reduces the $[H^+]$ in (b) / *OWTTE*; ***[2]***

4. (a) compounds with the same molecular formula and different structural formula/different structures; ***[1]***
Accept "same molecular formula but atoms orientated differently in space"

(b) (i) CH_3CH_2CHO ;
CH_3COCH_3 ;
acidified **and** $K_2Cr_2O_7$ /potassium dichromate/dichromate/ $Cr_2O_7^{2-}$;
CH_3CH_2CHO orange to green **and** CH_3COCH_3 no effect; ***[4]***
Accept Fehling's solution test or tollen's reagent test with appropriate results.
Accept any other correct isomer but the functional groups must be different and appropriate chemical test must be stated.

(ii) CH_3CH_2COOH ;
CH_3COOCH_3 / $HCOOC_2H_5$;
Na_2CO_3/sodium carbonate/reactive metal;
CH_3CH_2COOH – evolution of gas/fizzing / *OWTTE* **and**
CH_3COOCH_3 / $HCOOC_2H_5$ no effect; ***[4]***
Accept appropriate named indicator with correct colour change e.g. blue litmus turns red for the acid and no effect for the ester.
Accept any correct isomer but the functional groups must be different and appropriate chemical test must be stated.
Do not accept IR spectra or NMR as chemical tests.
Both isomers should be mentioned in the chemical test.

5. (a) $PV = nRT / P = \frac{nRT}{V}$;

$P = \frac{2.00 \times 8.31 \times 298}{1.00 \times 32.0} / \frac{0.0625 \times 8.31 \times 298}{1.00} / \frac{0.0625 \times 0.0821 \times 298}{1.00}$;

$P = 155$ kPa / 1.53 atm; ***[3]***

*Apply **–1(U)** rule*
*Award **[3]** for final answer.*

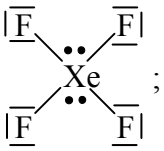
(b) higher (because M_r is lower);
number of moles/particles/molecules is higher / more frequent collisions with the wall of the container; ***[2]***

SECTION B

6. (a) (i) $\Delta H^{\ominus} = [-394 + (-558)] - [-1219]$;
$= +267 (\text{kJ mol}^{-1})$;
$\Delta S^{\ominus} = [214 + 70] - [112]$;
$= +172 \ (\text{JK}^{-1} \ \text{mol}^{-1})$;
$\Delta G^{\ominus} = 267 - (298)(0.172)$;
$= +216 (\text{kJ mol}^{-1})$; ***[6]***

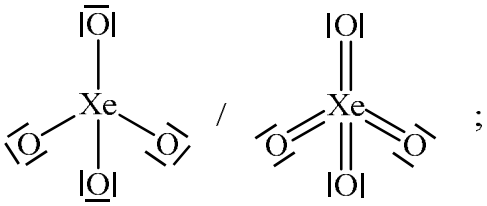
(ii) non-spontaneous as $\Delta G^{\ominus}$ is positive; ***[1]***

(iii) $\Delta G = \text{O} / \text{T} = \dfrac{\Delta H^{\ominus}}{\Delta S^{\ominus}}$;
267/0.172;
1550 K/1552 K/1277 °C/1279 °C ;
the factor $\text{T}\Delta S^{\ominus}$ predominates and $\Delta G^{\ominus}$ becomes negative / $\text{T}\Delta S^{\ominus}$ must be greater than ΔH for $\Delta G^{\ominus}$ to be negative; ***[4]***

(b) (i) 

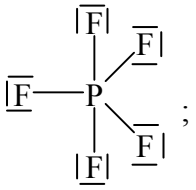
;

square planar/coplanar;



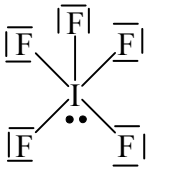
;

Tetrahedral/tetrahedron; ***[4]***
Do not accept two double and two single bonds around Xe.

(ii) 

;

trigonal bipyramidal;



;

square pyramidal/square-based pyramidal; ***[4]***

In part (i) and (ii), penalize missing lone pairs on fluorine and oxygen atoms once only.
Penalize missing or extra lone pairs on central atom every time.
Do not allow ECF for wrong Lewis structure.
Accept correct Lewis structures that does not display 3D shape.
Accept dots or crosses instead of lines.

(c) (i) (presence of) lone/non-bonding pairs;
dative covalent / coordinate; ***[2]***

(ii) $[Fe(Cl)_4]^- = +3$;
$[Fe(CN)_6]^{4-} = +2$; ***[2]***
*Award **[1 max]** if 3+ and 2+, 3 and 2 or III and II stated.*

(iii) catalytic activity/catalysts;
coloured compounds; ***[2]***
Accept paramagnetic

7. (a) (i) (exp. 1 and 2, [NO] constant, $[O_2]$ doubled rate doubles) first order with respect to O_2;
(exp. 2 and 3, $[O_2]$ doubled, [NO] doubled, rate increases by a factor of 8)
second order with respect to NO; ***[2]***
Accept alternative mathematical method

(ii) $\text{rate} = k[NO]^2[O_2]$; ***[1]***
Allow ECF from (i).

(iii) $\left(k = \dfrac{3.75\times10^{-3}}{(3.50\times10^{-2})^2(1.75\times10^{-2})}\right)$;
$= 1.75\times10^{2}$;
$dm^6\ mol^{-2}s^{-1}$; ***[2 max]***
Allow ECF from (ii).

(iv) 9.38×10^{-4} (mol $dm^{-3}\ s^{-1}$);
(since the volume is doubled), concentration is halved; ***[2]***
Allow ECF from (ii).

(v) $NO + NO \rightleftharpoons N_2O_2$ (fast);
$N_2O_2 + O_2 \rightarrow 2NO_2$ (slow);
second step is rate-determining step/rds;

OR

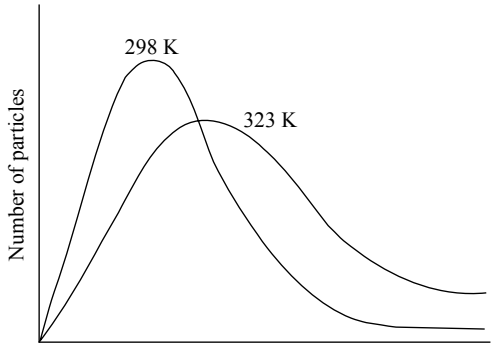
$NO + O_2 \rightleftharpoons NO_3$ (fast);
$NO_3 + NO \rightarrow 2NO_2$ (slow);
second step is rate determining step/rds; ***[3 max]***

*Do **not** allow the following 2 mechanisms.*

$NO + NO \rightleftharpoons NO_2 + N$ slow
$N + O_2 \rightarrow NO_2$ fast

$NO + NO + O_2 \rightarrow N_2O_4$ slow
$N_2O_4 \rightarrow 2NO_2$ fast

(b) kinetic energy of molecules increases;
frequency of collision increases;
greater proportion of molecules have energy greater than/equal to activation energy;
correct Boltzmann-energy distribution curves showing curve at higher temperature on the right side;
broadening of the curve; ***[5]***



Maxwell-Boltzmann distribution curve

(c) (i) (equilibrium shifted to the left) equilibrium concentration of NO/[NO] is reduced;
more gas molecules on the right hand side than on the left; ***[2]***

(ii) (equilibrium shifted to the left) equilibrium concentration of NO/[NO] is reduced;
forward reaction is exothermic; ***[2]***

(iii) no effect on the equilibrium concentration of NO/[NO];
catalyst increases the rate of forward and reverse reaction equally; ***[2]***

(d) $K_c = \frac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5}$;
mol dm^{-3}; ***[2]***

(e) increase in temperature;
K_c decreases; ***[2]***

8. (a) (i) $2H_2O \rightarrow O_2 + 4H^+ + 4e^- / 4OH^- \rightarrow O_2 + 2H_2O + 4e^-$;
bubbles (of colourless gas) evolved; ***[2]***
Do not accept oxygen evolved as an observation.

(ii) $Cu^{2+} + 2e^- \rightarrow Cu$;
brown deposit; ***[2]***
Accept copper deposited

(iii) electrolyte becomes acidic / pH decreases;
blue colour becomes lighter / concentration of Cu^{2+} decreases; ***[2]***
Do not accept colour change.

(iv) $Cu = 1$ mol **and** $O_2 = \frac{1}{2}$ mol ; ***[1]***

(v) copper(II) nitrate / $Cu(NO_3)_2$; ***[1]***
Accept any soluble copper(II) salt e.g. copper(II) ethanoate

(vi) copper anode/positive electrode dissolves / decrease in mass;
copper cathode/negative electrode increases in mass / brown deposit on cathode;
no change in colour of the electrolyte / no change in the concentration of Cu^{2+} / no change in pH; ***[3]***

(b) current/I **and** time/t; ***[1]***

(c) (i) 25°C **and** 1.0 mol dm^{-3} ; ***[1]***
Accept 298 K or 1.0 M but not 1 atm/101kPa

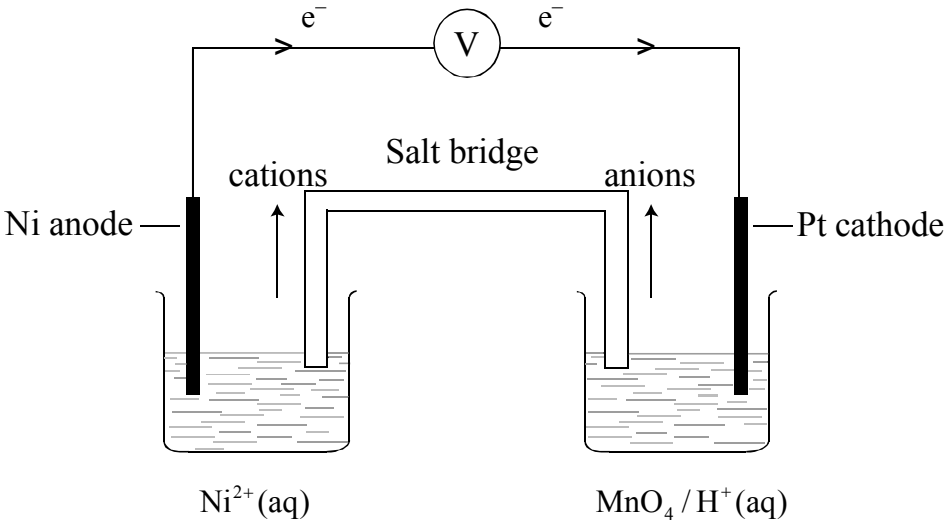
(ii) $2MnO_4^-(aq) + 16H^+(aq) + 5Ni(s) \rightarrow 2Mn^{2+}(aq) + 5Ni^{2+}(aq) + 8H_2O(l)$
correct reactants and products;
balancing; ***[2]***
Ignore if state symbols not written.
Do not accept electrons in the final equation.

(iii) reducing agent Ni(s)/Ni/Nickel;
Do not accept Ni^{2+}.
change in oxidation number 5 / $+7 \rightarrow +2$ / decreases by 5 ; ***[2]***

(iv) +1.74 V ; ***[1]***

(v) *A clear-labelled diagram consisting of:*
nickel anode;
platinum cathode;
electron movement from Ni to Pt;
salt bridge;
correct movement of cations / anions through salt bridge; ***[5]***

e.g.



(d) (voltaic cell)-spontaneous redox reaction / (electrolytic cell)-non-spontaneous redox reaction;
(voltaic cell)-chemical energy converted to electrical energy / (electrolytic cell)-electrical energy converted to chemical energy; ***[2]***
Accept anode is the positive electrode in an electrolytic cell and the negative electrode in a voltaic cell / cathode is the negative electrode in an electrolytic cell and the positive electrode in a voltaic cell.
For statements such as one electrolyte/two electrolyte and salt bridge/no salt bridge, award ***[1 max]****.*

9. (a) (i) $C\frac{85.6}{12.01}$ $H\frac{14.4}{1.01}$;

No penalty for using integer A_r values.

Empirical formula CH_2;

Molecular formula C_4H_8; ***[3]***

(ii) $(CH_3)_2C{=}CH_2$;

6:2 / 3:1; ***[2]***

(iii) $CH_3CH{=}CHCH_3$;

but-2-ene/2-butene; ***[2]***

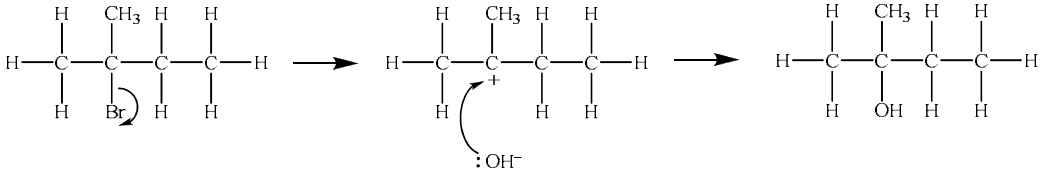
(iv) dehydration / elimination;

$CH_2{=}CHCH_2CH_3$;

$CH_3CH_2CH_2CH_2OH$; ***[3]***

Accept butan-2-ol

(b) (i)



curly arrow showing C–Br bond fission;

formation of carbonium ion;

curly arrow showing attack by OH^- on carbon atom;

product; ***[4]***

(ii) step 1 **and** because it is a slow step / because it has high activation energy / because it involves bond breaking; ***[1]***

(c) (i) less because C–Cl bond is stronger; ***[1]***

(ii) equal because first order kinetics / rate determining step does not involve KOH / *OWTTE*; ***[1]***

(d) (i) sp^2 (hybridization);

angle 120°;

symmetrical / planar/flat / hexagonal structure;

delocalization of electrons / resonance hybrid/all carbon to carbon bonds are equal; ***[4]***

(ii) one;

all the hydrogen in benzene are equivalent / *OWTTE*; ***[2]***

Accept two for the first mark if TMS / reference is mentioned for the second mark.

(e) (i) –360 (kJ mol^{-1}); ***[1]***

(ii) benzene is more stable because of delocalization / does not contain three double bonds/delocalization energy is 153 kJ/mol; ***[1]***