N11/4/CHEMI/SP2/ENG/TZ0/XX/M

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MARKSCHEME

November 2011

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 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 <u>underlined</u> 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) *Ionic:*
(electrostatic) attraction between oppositely charged ions/cations and anions/positive and negative ions;
Do not accept answers such as compounds containing metal and non-metal are ionic.

Metallic:
(electrostatic attraction between lattice of) positive ions/cations/nuclei and delocalized electrons / (bed of) positive ions/cations/nuclei in sea of electrons / *OWTTE*; ***[2]***

(b) (i) T: 4 **and** m: 3 **and** p: 3; ***[1]***

(ii) $n = (65.0 / 65.02) = 1.00$ (mol) ; ***[1]***
No penalty for using whole number atomic masses.

(iii) $n(\mathrm{N_2}) = \left(\frac{3}{2} \times 1.00 =\right) 1.50$ (mol) ;

$T = \left((25.00 + 273.15) =\right) 298.15\ \mathrm{K}\ /\ (25.00 + 273) = 298\ \mathrm{K}$;

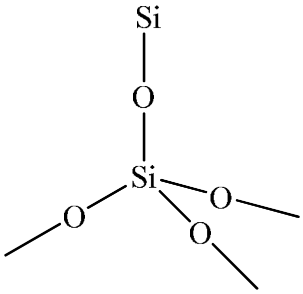
$p = 1.08 \times 1.01 \times 10^5\ \mathrm{Pa}\ /\ 1.08 \times 1.01 \times 10^2\ \mathrm{kPa}\ /\ 1.09 \times 10^5\ \mathrm{Pa}\ /\ 1.09 \times 10^2\ \mathrm{kPa}$;

$V = \frac{nRT}{p} = \frac{(10^3)(1.50)(8.31)(298.15/298)}{(1.08 \times 1.01 \times 10^5)} = 34.1\ (\mathrm{dm^3})$; ***[4]***

*Award **[4]** for correct final answer.*
*Award **[3 max]** for 0.0341 (dm^3) or 22.7 (dm^3).*
*Award **[3 max]** for 34.4 (dm^3).*
*Award **[2 max]** for 22.9 (dm^3).*
*Award **[2 max]** for 0.0227 (dm^3).*
*Award **[2 max]** for 0.034 (dm^3).*

(c) (i) sodium could react violently with any moisture present / sodium is (potentially) explosive / sodium (is dangerous since it is flammable when it) forms hydrogen on contact with water / *OWTTE*; ***[1]***
Do not accept answers such as sodium is dangerous or sodium is too reactive.

(ii) *Structure:*
drawing of giant structure showing tetrahedrally arranged silicon;
Minimum information required for mark is Si and 4 O atoms, in a tetrahedral arrangement (not 90° bond angles) but with each of the 4 O atoms showing an extension bond.



Bonding:
(giant/network/3D) covalent; ***[2]***

(d) (i) $\left(\frac{34.1}{0.0400}\right) = 853\ \text{dm}^3\ \text{s}^{-1} / \left(\frac{1.50}{0.0400}\right) = 37.5\ \text{mol s}^{-1}$; ***[1]***
Accept 851 dm^3 s^{-1}.
Units required for mark.

(ii) more energetic collisions / more species have energy $\geq E_a$; ***[1]***
Allow more frequent collisions / species collide more often.

2. (a)

Symbol	$^{59}Co^{3+}$	^{60}Co	^{125}I
Number of protons	27	27	53
Number of neutrons	32	33	72
Number of electrons	24	27	53

[2]

*Award **[2]** for all four correct.*
*Award **[1]** for two or three correct.*

(b) Co-60 emits (penetrating) gamma radiation/rays / *OWTTE*; ***[1]***
Allow because Co-60 emits radiation which kills/treats cancer cells.
Do not allow answers such as Co-60 is radioactive or Co-60 treats cancer as single statements.

3. (a) (i) *Cell showing:*

container, liquid, electrodes **and** power supply;

No labels are required, but do not award mark if incorrect labels are used (e.g. sodium chloride solution). A line must be drawn on the container to indicate the presence of a liquid. If power supply is a battery then do not penalize electrodes incorrectly assigned as + or –.

Positive electrode (anode):

chlorine (gas) / $Cl_2(g)$

and

Negative electrode (cathode):

sodium (liquid) / $Na(l)$; **[2]**

Ignore state symbols in (i) but do not award mark for Cl.

(ii) *Oxidation half-equation:*

$2Cl^- \rightarrow Cl_2 + 2e^-$ / $Cl^- \rightarrow \frac{1}{2}Cl_2 + e^-$

and

Reduction half-equation:

$Na^+ + e^- \rightarrow Na$ / $2Na^+ + 2e^- \rightarrow 2Na$;

Allow e instead of e^-.

Overall cell reaction:

$2NaCl(l) \rightarrow 2Na(l) + Cl_2(g)$ / $NaCl(l) \rightarrow Na(l) + \frac{1}{2}Cl_2(g)$; **[2]**

*Award **[1]** for oxidation **and** reduction half-equations.*

*Award **[1]** for overall cell reaction, including correct state symbols.*

Accept $Na^+(l) + Cl^-(l)$ instead of NaCl(l) as a reactant.

Penalize equilibrium arrows once only.

(b) ions not free to move when solid / ions in rigid lattice / *OWTTE*; **[1]**

(c) Al less dense (compared to Fe) / Al forms a protective (oxide) layer / Fe rusts / *OWTTE*; **[1]**

Do not accept Al is lighter.

4. (a) energy required to break (1 mol of) a bond in a gaseous molecule/state;
Accept energy released when (1 mol of) a bond is formed in a gaseous molecule/ state / enthalpy change when (1 mol of) bonds are formed or broken in the gaseous molecule/state.

average values obtained from a number of similar bonds/compounds / *OWTTE*; ***[2]***

(b) $CH_3(CH_2)_3OH\,(l) + 6O_2\,(g) \rightarrow 4CO_2\,(g) + 5H_2O\,(l)$; ***[1]***
Allow C_4H_9OH or $C_4H_{10}O$ for $CH_3(CH_2)_3OH$.
Ignore state symbols.

(c) *Bonds broken:*
(6)(O=O) + (3)(C–C) + (1)(O–H) + (1)(C–O) + (9)(C–H) /
((6)(498) + (3)(347) + (1)(464) + (1)(358) + (9)(413) =)8568 (kJ mol^{-1}) ;

Bonds formed:
(8)(C=O) + (10)(O–H) / ((8)(746) + (10)(464) =)10608 (kJ mol^{-1}) ;

ΔH = (8568 – 10608 =) – 2040 (kJ mol^{-1}) ; ***[3]***
*Award **[3]** for correct final answer.*
*Award **[2]** for +2040 (kJ mol^{-1}).*

(d) hydrogen bonding in butan-1-ol;
stronger than dipole-dipole attractions in butanal; ***[2]***
Accept converse argument.
Do not penalize dipole-dipole bonding instead of dipole-dipole attractions.

SECTION B

5. (a) $2Na(s) + S(s) \rightarrow Na_2S(s)$ / $2Na(s) + \frac{1}{2}S_2(g) \rightarrow Na_2S(s)$ / $16Na(s) + S_8(s) \rightarrow 8Na_2S(s)$;
Ignore state symbols.

Na: 2, 8, 1 **and** S: 2, 8, 6 ;

Na^+: 2, 8 **and** S^{2-}: 2, 8, 8 ;

reduced since it has gained electrons / reduced since oxidation number has decreased; ***[4]***
Do not award mark if incorrect oxidation numbers are given.

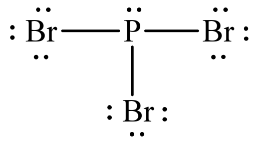
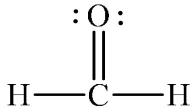
(b) *Na*, *Mg*: basic
Al: amphoteric
Do not accept amphiprotic.

Si to Cl: acidic
*Award **[2]** for all three listed sets correct, **[1]** for one or two listed sets correct.*
*Award **[1]** for stating oxides become more basic towards left/Na and more acidic towards right/Cl.*
Do not penalize incorrect formulas of oxides.

$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$;

$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$; ***[4]***
Ignore state symbols.
Allow $P_2O_5(s) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$.

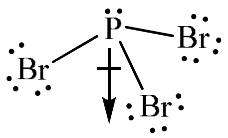
(c) (i)

PBr_3	*HCOH*
Lewis structure:  ; *Allow x's, dots or lines to represent electrons.* *Penalize missing lone pairs on terminal atoms once only for the two Lewis structures.* *Shape:* trigonal/triangular pyramidal; *Allow pyramidal.* *Bond angle:* less than 109.5°; *Allow any angle less than 109.5° but greater than or equal to 100° (experimental value is 101°).*	*Lewis structure:*  ; *Allow x's, dots or lines to represent electrons.* *Penalize missing lone pairs on terminal atoms once only for the two Lewis structures.* *Shape:* trigonal/triangular planar; *Bond angle:* 120°;

[6]

Do not allow ECF in this question from incorrect Lewis structure.

(ii) Br more electronegative than P / P–Br bond polar;
bond dipoles do not cancel / there is a net dipole / asymmetric distribution of electron cloud;



[2]

Allow polar bonds do not cancel or that it is an asymmetric molecule.
*Award **[2]** for diagram showing net dipole moment as shown.*

(d) (i) chromium(III) oxide; ***[1]***
Do not award mark for chromium oxide.

(ii) chromium is neither oxidized or reduced since there is no change in oxidation number/+6 to +6; ***[1]***

(iii) substance reduced / causes other substance to be oxidized / increase oxidation number of another species / gains electrons / *OWTTE*;

Oxidizing agent:
$Cr_2O_7^{2-}$ / dichromate (ion); ***[2]***

6. (a) (i) $(K_c) = \frac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5}$; ***[1]***

No mark if square brackets are omitted or are incorrect.

(ii) right;
right;
right;
no change; ***[4]***

(b) minimum energy needed (by reactants/colliding particles) to react/start/initiate a reaction; ***[1]***
Allow energy difference between reactants and transition state.

(c) catalyst;
regenerated at end of reaction / *OWTTE*; ***[2]***

(d) (i) (system) absorbs/takes in heat from surroundings / *OWTTE*; ***[1]***
Allow standard enthalpy change/ $\Delta H^{\ominus}$ positive.
Allow bond breaking more energetic then bond formation / OWTTE.
Absorbs/takes in heat alone not sufficient for mark.

(ii) *Curve showing:*
general shape of Maxwell-Boltzmann energy distribution curve;
correct position of E_a (catalysed) **and** E_a (uncatalysed);
labelled y-axis: probability of particles (with that kinetic energy) **and** *labelled x-axis:* (kinetic) energy; ***[3]***
Allow number/fraction/proportion of particles (with kinetic energy) for y-axis label, but do not allow amount or particles.

*Award **[2 max]** if a second curve is drawn, but at a higher temperature, M2 will not be scored here.*

(e) (i) change in concentration of reactant/product with time / rate of change of concentration; ***[1]***

Increase can be used instead of change for product or decrease can be used instead of change for reactant.

Allow mass/amount/volume instead of concentration.

Do not accept substance.

(ii) pressure is lower/moderate **and** temperature is higher in Haber process / ~ 200 atm (pressure) **and** ~ 700 K (temperature) used in Haber process;

Pressure:

high pressure shifts equilibrium to right;

high pressure (faster rate but) expensive/dangerous / greater capital and running costs;

Temperature:

low temperature shifts equilibrium (even further) to right;

low temperature gives slower rate (but high yield);

high pressure increases yield **and** lower temperature decreases rate;

Accept converse argument.

(not possible to have high yield and fast rate simultaneously therefore) compromise needed / *OWTTE*; ***[4 max]***

(f) $q = mc\Delta T = 2.450 \times 10^5 = (8.500 \times 10^3)(0.4490)(T_f - 15.25)$;

$T_f = 79.44\ ^\circ\text{C} / \Delta T = 64.19\ (^\circ\text{C}/\text{K})$;

$T_f = (79.44 + 273) = 352\ (\text{K})$; ***[3]***

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

Accept the use of 273.15 K instead of 273 K giving final value of 352.59 K.

*For M1 and M2 award **[1 max]** for use of $q = mc\Delta T$ if incorrect units of m and c are used.*

7. (a) same functional group;
successive/neighbouring members differ by CH_2;
same general formula;
similar chemical properties;
gradation in physical properties; ***[2 max]***

(b) (i) ***Y***: 4-methylpentanal;
Z: 4-methylpentanoic acid; ***[2]***
*Award **[1]** if student has correct endings for both molecules but has used incorrect stem.*

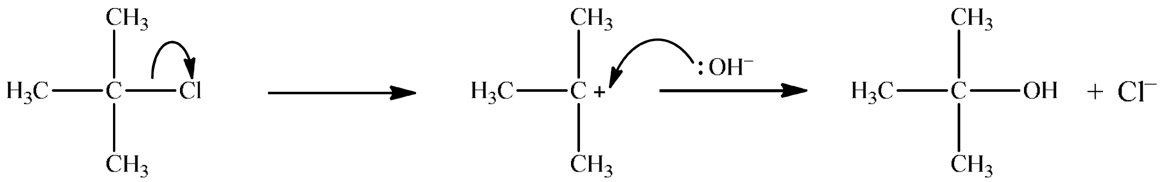
(ii) *For both reactions reagents:*
named suitable acidified oxidizing agent;
Suitable oxidizing agents are potassium dichromate(VI)/$K_2Cr_2O_7$ / sodium dichromate(VI)/$Na_2Cr_2O_7$ / dichromate/$Cr_2O_7^{2-}$ / potassium manganate(VII)/ potassium permanganate/$KMnO_4$ / permanganate/manganate(VII)/MnO_4^-.
Accept H^+/H_2SO_4 instead of sulfuric acid and acidified.
Allow potassium dichromate or sodium dichromate (i.e. without (VI)) or potassium manganate (i.e. without (VII).

Conditions:
distillation for **X** to **Y and** reflux for **X** to **Z**; ***[2]***
*Award **[1]** if correct reagents and conditions identified for one process only.*

(iii) acid partially dissociates/ionizes; ***[1]***

(iv) **Y** more volatile than **Z**;
hydrogen bonding in carboxylic acid/**Z**; ***[2]***
Accept converse argument.

(c) *Mechanism:*



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 curly arrow originating on H of HO^-.

formation of $(CH_3)_3COH$ **and** Cl^-; ***[4]***
If candidate draws S_N2 mechanism instead of S_N1 then only the last marking point is available.

(d) (i) $\left(\left(\frac{2\times 1.01}{18.02}\right)(0.089)=\right)1.0\times 10^{-2}$ g H **and** $\left(\left(\frac{12.01}{44.01}\right)(0.872)=\right)2.38\times 10^{-1}$ g C ;

$\left(\left(\frac{0.238}{1.30}\right)(100)=\right)18.3\%$ C ;

$\left(\frac{1.0\times 10^{-2}}{1.30}\right)(100)=0.77\%$ H ; ***[3]***

*Award **[3]** for correct final answer of 18.3 % C and 0.77 % H without working.*
Allow whole numbers for molar masses.

(ii) $\left((1.75)\left(\frac{35.45}{143.32}\right)=\right)0.433$ g (Cl) **and** $\left(\left(\frac{0.433}{0.535}\right)(100)=\right)80.9\%$ (Cl) ; ***[1]***

Allow whole numbers for molar masses.

(iii) $\left(\frac{18.3}{12.01}\right)=1.52$ mol C **and** $\left(\frac{0.77}{1.01}\right)=0.76$ mol H **and** $\left(\frac{80.9}{35.45}\right)=2.28$ mol Cl ;

Allow whole numbers for atomic masses.

Empirical formula $=C_2HCl_3$;

*Award **[2]** for correct empirical formula without working.*

$M_r=(24.02+1.01+106.35)=131.38$, so molecular formula is C_2HCl_3 ; ***[3]***

*Award **[3]** for correct final answer without working.*
Allow whole numbers for atomic masses.