M11/4/CHEMI/SP2/ENG/TZ1/XX/M

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MARKSCHEME

May 2011

CHEMISTRY

Standard Level

Paper 2

10 pages

General Marking Instructions

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. 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.

9. Only consider units at the end of a calculation.

10. Significant digits should only be considered in the final answer. Penalize 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*

11. 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.

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) *amount of energy required to break bonds of reactants*
$3\times413+358+464+1.5\times498$ (kJ mol^{-1}) / 2808 (kJ mol^{-1});

amount of energy released during bond formation of products
$4\times464+2\times746$ (kJ mol^{-1}) / 3348 (kJ mol^{-1});

$\Delta H = -540$ (kJ mol^{-1}); ***[3]***
*Award **[3]** for correct final answer.*
*Award **[2]** for (+)540.*
*If old Data Booklet is used accept answer: –535 (kJ mol^{-1}) or award **[2]** for (+)535.*

(b) (i) m(methanol) = (80.557 – 80.034) = 0.523 (g);
$n(\text{methanol}) = \left(\frac{0.523\text{ g}}{32.05\text{ g mol}^{-1}}\right) = 0.0163$ (mol); ***[2]***
*Award **[2]** for correct final answer.*

(ii) ΔT = (26.4 – 21.5) = 4.9 (K);
$q = (mc\Delta T =)\ 20.000\times4.18\times4.9$ (J) / $20.000\times4.18\times4.9\times10^{-3}$ (kJ);
0.41 (kJ); ***[3]***
*Award **[3]** for correct final answer.*

(iii) $\Delta H_c^{\ominus} = -\frac{0.41\text{ (kJ)}}{0.0163\text{ (mol)}} / -25153$ (J mol^{-1});
= –25 (kJ mol^{-1}); ***[2]***
*Award **[2]** for correct final answer.*
*Award **[1]** for (+)25 (kJ mol^{-1}).*

(c) (i) bond enthalpies are average values/differ (slightly) from one compound to another (depending on the neighbouring atoms) / methanol is liquid not gas in the reaction; ***[1]***

(ii) not all heat produced transferred to water / heat lost to surroundings/environment / *OWTTE* / incomplete combustion (of methanol) / water forms as $H_2O(l)$ instead of $H_2O(g)$; ***[1]***
Do not allow just "heat lost".

2. (a) argon has a greater proportion of heavier isotopes / *OWTTE* / argon has a greater number of neutrons; ***[1]***

(b) 19 protons **and** 18 electrons; ***[1]***

(c) 2, 8, 8; ***[1]***
Accept $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$.

3. (a) $(K_c =) \frac{[CH_3OH]}{[CO][H_2]^2}$; ***[1]***

Do not award mark if incorrect brackets are used or brackets are missing.

(b) (i) amount (of methanol)/product decreases / less methanol;
(forward reaction) exothermic / reverse reaction endothermic / *OWTTE*; ***[2]***

(ii) amount (of methanol)/product increases / more methanol;
3 gas molecules/mol → 1 / decrease in volume / fewer gas molecules on right hand side/products / more gas molecules on left hand side/reactants; ***[2]***

(c) high pressure expensive / greater cost of operating at high pressure;
lower temperature – lower (reaction) rate; ***[2]***

(d) increases rate of forward and reverse reactions (equally) / lowers activation energy/E_a (of both the forward and reverse reaction equally) / provides alternative path with lower activation energy/E_a; ***[1]***
Accept reactants adsorb onto the catalyst surface and bonds weaken resulting in a decrease in the activation energy.

4. (a) (i) (10% 1000 g =) 100 g ethanol **and** (90% 1000 g =) 900 g octane; ***[1]***

(ii) n(ethanol) = 2.17 mol **and** n(octane) = 7.88 mol; ***[1]***

(iii) $E_{\text{released from ethanol}} = (2.17 \times 1367) = 2966$ (kJ);
$E_{\text{released from octane}} = (7.88 \times 5470) = 43104$ (kJ);

total energy released = $(2966 + 43104) = 4.61 \times 10^4$ (kJ); ***[3]***
*Award **[3]** for correct final answer.*
Accept answers using whole numbers for molar masses and rounding.

(b) greater;
fewer intermolecular bonds/forces to break / vaporization is endothermic / gaseous fuel has greater enthalpy than liquid fuel / *OWTTE*; ***[2]***
M2 cannot be scored if M1 is incorrect.

SECTION B

5. (a) (i) the amount of energy required to remove one (mole of) electron(s);
from (one mole of) an atom(s) in the gaseous state; ***[2]***

(ii) greater positive charge on nucleus / greater number of protons / greater core charge;
greater attraction by Mg nucleus for electrons (in the same shell) / smaller atomic radius; ***[2]***

(b) (i) calcium ionic charge is twice/greater than the potassium ionic charge / calcium has more delocalized electrons than potassium;
greater attraction of delocalized electrons and Ca^{2+} / less attraction between the delocalized electrons and K^+; ***[2]***
Do not accept calcium ion has a 2^+ without comparison to K^+.

(ii) Na_2O ionic/(stronger electrostatic) attractions between Na^+ and O^{2-};
SO_3 has (weak) intermolecular/van der Waals'/London/dispersion/dipole-dipole attractions;
intermolecular/van der Waals'/London/dispersion/dipole-dipole forces are weaker/more easily broken than (strong) ionic bonds / ionic bonds are stronger/harder to break than intermolecular bond/van der Waals'/London/dispersion/dipole-dipole forces; ***[3]***

(c) (i) acid is a proton/H^+ donor **and** base is a proton/H^+ acceptor;
H_2CO_3/CH_3COOH **and** NaOH/KOH/$Ba(OH)_2$; ***[2]***
Accept any suitable examples.

(ii) *Chemical* ***[2 max]***
reaction with reactive metal/Mg/Zn/carbonate/hydrogen carbonate;
hydrochloric acid would react faster/more vigorously / ethanoic acid would react slower/less vigorously;

OR

react with alkali;
temperature change will be more for hydrochloric acid / temperature change will be less for ethanoic acid;

Physical ***[2 max]***
conductivity;
hydrochloric acid will conduct more/higher / ethanoic acid will conduct less/lower; ***[4 max]***
Accept other suitable examples.

(iii) black coffee;
10^3/1000 times; ***[2]***

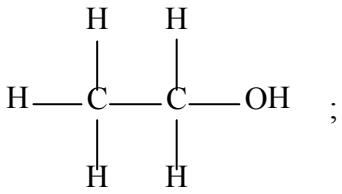
(d) $Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$;
$SO_3(l) + H_2O(l) \rightarrow H_2SO_4(aq)$;
Ignore state symbols.
Na_2O: basic **and** SO_3: acidic; ***[3]***

6. (a) boiling points increase (from the first member to the fifth member);
increasing size of molecule/area of contact/number of electrons (from the first to the fifth member);
strength of intermolecular/van der Waals'/London/dispersion forces increase / more energy required to break the intermolecular bonds (from first member to fifth member); ***[3]***

(b) same general formula;
successive members differ by CH_2;
same functional group / similar/same chemical properties;
gradual change in physical properties; ***[2 max]***
Accept specific physical property such as melting point, boiling point only once.

(c)

A:



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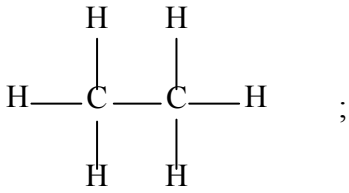
B:



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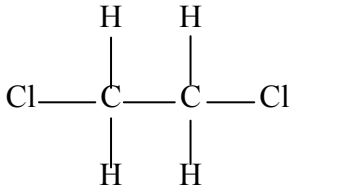
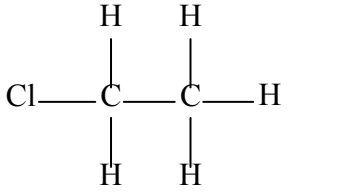
C:



;

1,2-dichloroethane;

D:



;

Accept condensed formulas. ***[5]***
Penalize missing hydrogens only once.

(d) add bromine water/bromine;
pentane no change/stays brown **and** pent-1-ene decolourizes bromine water/bromine;

OR

add acidified $KMnO_4$;
pentane no change/stays purple **and** pent-1-ene decolourizes acidified $KMnO_4$; ***[2 max]***
Accept any correct colour change.
Do not accept 'clear' instead of 'colourless'.

(e) **E**: primary **and F**: secondary;
G: primary;
G / **E**: only one alkyl group/2 H atoms attached to the carbon atom attached to the Cl / only one carbon atom attached to the carbon atom attached to the Cl;
F: two alkyl groups/1 H atom attached to the carbon atom attached to the Cl / two carbon atoms attached to the carbon atom attached to the Cl; ***[4]***

(f) *Initiation:*
$Cl_2 \xrightarrow{\text{UV/}hf\text{/}hv\text{/heat}} 2Cl\bullet$;
Reference to UV/hf/hv/heat must be included.

Propagation:
$Cl\bullet + CH_4 \rightarrow CH_3\bullet + HCl$;
$CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$;

Termination:
$Cl\bullet + Cl\bullet \rightarrow Cl_2$ / $CH_3\bullet + Cl\bullet \rightarrow CH_3Cl$ / $CH_3\bullet + CH_3\bullet \rightarrow C_2H_6$; ***[4]***
Allow representation of radical without • (e.g. Cl, CH_3) if consistent throughout mechanism.
If representation of radical (i.e. •) is inconsistent, penalize once only.

7. (a) *Group*: number of outershell/valence electrons;
Period: number of occupied (electron) shells; ***[2]***

(b) C: 2 **and** Si: 3; ***[1]***

(c) *Award **[2 max]** for three of the following features:*

Bonding

*Graphite **and** C_{60} fullerene:* covalent bonds **and** van der Waals'/London/dispersion forces;
Diamond: covalent bonds (and van der Waals'/London/dispersion forces);

Delocalized electrons

*Graphite **and** C_{60} fullerene:* delocalized electrons;
Diamond: no delocalized electrons;

Structure

Diamond: network/giant structure / macromolecular / three-dimensional structure **and** *Graphite:* layered structure / two-dimensional structure / planar;
C_{60} fullerene: consists of molecules / spheres made of atoms arranged in hexagons/pentagons;

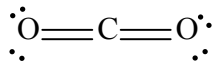
Bond angles

Graphite: 120^{o} **and** *Diamond:* 109^{o};
C_{60} fullerene: bond angles between $109–120^{o}$;
*Allow Graphite: sp^2 **and** Diamond: sp^3.*
*Allow C_{60} fullerene: sp^2 **and** sp^3.*

Number of atoms each carbon is bonded to

*Graphite **and** C_{60} fullerene:* each C atom attached to 3 others;
Diamond: each C atom attached to 4 atoms / tetrahedral arrangement of C (atoms); ***[6 max]***

(d) (i)



;
linear **and** 180^{o}; ***[2]***
Accept crosses, lines or dots as electron pairs.

(ii) network/giant structure / macromolecular;
each Si atom bonded covalently to 4 oxygen atoms **and** each O atom bonded covalently to 2 Si atoms / single covalent bonds; ***[2]***
*Award **[1 max]** for answers such as network-covalent, giant-covalent or macromolecular-covalent.*
Both M1 and M2 can be scored by a suitable diagram.

(iii) *Silicon dioxide:* strong/covalent bonds in network/giant structure/macromolecule;
Carbon dioxide: weak/van der Waals'/dispersion/London forces between molecules; ***[2]***

(e) triple (covalent) bond;
one electron pair donated by oxygen to carbon atom / dative (covalent)/coordinate (covalent) bond; ***[2]***
*Award **[1 max]** for representation of* $C \equiv O$.
*Award **[2]** if CO shown with dative covalent bond.*

(f) $2809 = 3.10 \times 30 + 28x + 29(96.9 - x)$;
% $^{28}Si = (93 + 2810.1 - 2809) = 94.1$ %; ***[2]***
*Award **[2]** for correct final answer.*

(g) ^{14}C **and** radiocarbon dating/(tracer in) medical/scientific tests;
^{11}C **and** (tracer in) medical/scientific tests; ***[1 max]***