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Mark Scheme (Results)

June 2011

GCE Chemistry (6CH01) Paper 01
The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the <u>meaning</u> of the phrase or the actual word is **essential** to the answer.

ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear

- select and use a form and style of writing appropriate to purpose and to complex subject matter

- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1 (a)	C	**1**

Question Number	Correct Answer	Mark
1 (b)	B	**1**

Question Number	Correct Answer	Mark
1 (c)	D	**1**

Question Number	Correct Answer	Mark
1 (d)	B	**1**

Question Number	Correct Answer	Mark
2	A	**1**

Question Number	Correct Answer	Mark
3	C	**1**

Question Number	Correct Answer	Mark
4	C	**1**

Question Number	Correct Answer	Mark
5	B	**1**

Question Number	Correct Answer	Mark
6	D	**1**

Question Number	Correct Answer	Mark
7	A	**1**

Question Number	Correct Answer	Mark
8	C	**1**

Question Number	Correct Answer	Mark
9	C	**1**

Question Number	Correct Answer	Mark
10	B	**1**

Question Number	Correct Answer	Mark
11	A	**1**

Question Number	Correct Answer	Mark
12	D	**1**

Question Number	Correct Answer	Mark
13 (a)	A	**1**

Question Number	Correct Answer	Mark
13 (b)	D	**1**

Question Number	Correct Answer	Mark
13 (c)	B	**1**

Question Number	Correct Answer	Mark
14	C	**1**

Question Number	Correct Answer	Mark
15	B	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
16 (a)	**First mark** The energy (allow enthalpy / heat) required (allow change) per mole **(1)** **Second mark** to form (gaseous) singly charged positive ions Or to remove (1 mole of) electrons **(1)** **Third mark** from **gaseous** atoms (of the element) **(1)** $X(g) \longrightarrow X^{+}(g) + e^{(-)}$ scores last 2 marks Ignore standard conditions Per mole scores at any point	Energy / enthalpy produced Just gaseous element	**3**

Question Number	Acceptable Answers	Reject	Mark
16 (b)	Nuclear charge / effective nuclear charge / number of protons / atomic number increases **(1)** **Two of** (Outer) electrons in the **same** (quantum) shell / **same** number of electron shells **(1)** Shielding (of nucleus)(about) the same **(1)** Distance from nucleus/atomic radius less **(1)**	charge density orbitals, sub-shell	**3**

Question Number	Acceptable Answers	Reject	Mark
16 (c)	**Route 1** Electrons (in the p sub-shell) are **paired** (for the first time) (in S) / two electrons occupy the same (p) orbital / full orbital / electrons-in-boxes diagram **(1)** **repulsion** between the (paired) electrons (reduces IE) **(1)** **Route 2** P has a half-filled p sub-shell / half-filled p orbitals which is stable **(1)** (on ionization) S gains a half-filled p sub-shell / half-filled p orbitals **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
16 (d)	200 – 490 (kJ mol^{-1})	Negative values	**1**

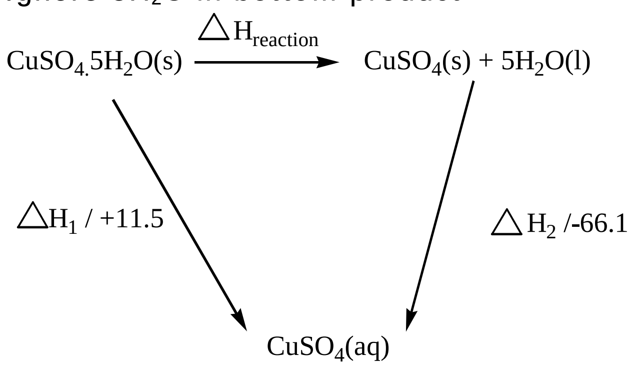
Question Number	Acceptable Answers	Reject	Mark
17 (a)	Do not penalize the use of A_r (Mg) = 24.3 at any stage in this question. Penalize SF errors (1 SF, incorrect SF (eg. 0.02) and incorrect rounding to 2 SF (e.g. 0.016)) only once in parts (a – d) Allow 0.0166 Allow fractions (e.g. 1/60) Amount Mg = (0.4 ÷ 24) = 0.016666 = 0.0167 (mol) Allow Amount Mg = (0.4 ÷ 24.3) = 0.016461 = 0.0165 (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)	Amount HCl = 1.5 x 22.2/1000 = 0.033333 = 0.0333 (mol) Allow Amount HCl = 2 x answer in (a)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (c)	Amount of H_2 = 400 ÷ 24 000 = 0.016666 = 0.0167 (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (d)	Ratio mol Mg:HCl:H_2 = 0.0167 (0.165) : 0.0333 : 0.0167 = 1:2:1 Allow answers in which the mole ratios of the reactant and products are compared separately	Just stating the molar ratio	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (e)	M_r ($MgCl_2$) = 24 + 2 x 35.5 = 95 **(1)** Mol $MgCl_2$ = (mol Mg) = 0.0166666 (or 0.0167) **(1)** Mass $MgCl_2$ = 95 x 0.0166666 = 1.58 (g) **3 sf (1)** Or 95 x 0.0167 = 1.59 (g) 3sf Or 95.3 x 0.0166666 = 1.59 Or 95 x 0.0165 = 1.58 Or 95.3 x 0.0165 = 1.57 Correct answer with no working scores **(3)** TE on 17(a)		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (a) (i)	Product in box: $CuSO_4$**(<u>aq</u>) (1)** **Either** Mark the arrows and then the labels: Two downward arrows **(1)** labelled with symbols or values with or without units **(1)** **OR** Mark each arrow and label separately Downward arrow & ΔH_1 or value **(1)** Downward arrow & ΔH_2 or value **(1)** Allow reversed arrows **with** reversed signs on ΔH Ignore any other labels on the arrows. Ignore $5H_2O$ in bottom product 		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (a)(ii)	**Award higher mark from:** **Route 1** **Mark the calculation based on their cycle** TE from (a)(i) ignoring incorrect bottom product **Route 2** **Mark a calculation which is independent of the cycle** $\triangle H_{reaction} = \triangle H_1 - \triangle H_2$ stated or implied $= +11.5 - (-66.1)$ **(1)** $= (+)\ 77.6\ (\text{kJ mol}^{-1})$ **(1)** Correct answer alone scores **(2)** **−**77.6 (kJ mol^{-1}) alone or from a correct addition scores **(1)**		**2**

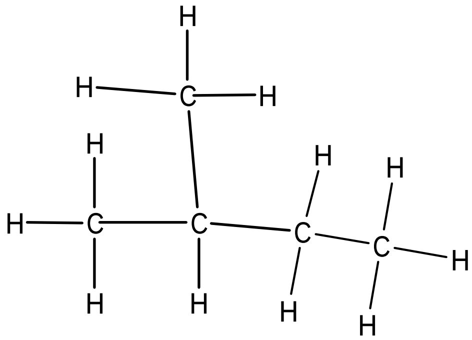
Question Number	Acceptable Answers	Reject	Mark
18 (b)	Dehydration reaction cannot be controlled OR temperature change (of dehydration reaction) cannot be measured OR $CuSO_4.5H_2O$ would need heating (so temperature change cannot be measured) OR impossible to add exact amount of water (to obtain value by reverse process) OR cannot mix solid with water to obtain perfect crystals	Temperature of solid / crystals cannot be measured	**1**

Question Number	Acceptable Answers	Reject	Mark
***18 (c)(i)**	First & second marks stand alone 1. Pipette/burette / measuring cylinder / balance to transfer (a known amount of) (water) **(1)** 2. to (expanded) polystyrene cup / calorimeter / any *insulated* container allow coffee / plastic cup **(1)** Third & fourth marks only awarded if correct chemicals **and** procedure used 3. add solid and **stir** (allow mix or shake) mixture **(1)** 4. measure initial **and** final temperature allow temperature change **(1)**	Just mass / volume measured Temperature **increase** unless exothermic penalised in (b)	**4**

Question Number	Acceptable Answers	Reject	Mark
18 (c)(ii)	Any three from: • heat transfer (from surroundings) (allow loss or gain) • approximation in (specific) heat capacity of solution • neglecting (specific) heat capacity of calorimeter/apparatus (allow energy absorbed by the apparatus) • reaction / dissolving may be incomplete/slow • temperature change is very small (and difficult to measure) • Density of solution is taken as the same as water • conditions not standard (allow)	Errors in calculation including adding mass of solid to mass of water loss of reagents / water incomplete combustion Just 'difficult to measure'	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(i)	C_nH_{2n+2} or any symbol in place of n Ignore C_5H_{12}		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(ii)	(structural / chain) isomers		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iii)	 (any orientation of this structure) Ignore non-displayed formulae	Structures in which **any** bonds or atoms are omitted Structures with CH_3 groups	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iv)	2,2-dimethylpropane **(1)** Allow dimethylpropane, 2-dimethylpropane 2,2 dimethylpropane, 2 dimethylpropane Ignore hyphens, commas, spaces		**1**

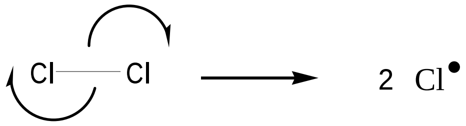
Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	$CH_4 + 1½O_2 \rightarrow CO + 2H_2O$ Formulae **(1)** balance **(1)** Or multiples Ignore state symbols No TE on **any** other species		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(ii)	Insufficient / not excess oxygen / air	Reactant does not react completely with oxygen Just 'methane in excess'	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(iii)	**Any two from** **CO** is toxic / poisonous (allow harmful) **(1)** Less energy is produced (allow (methane) becomes a less efficient fuel) **(1)** Unburned hydrocarbons react to form compounds which are toxic / harmful **(1)** Allow sooty deposits / carbon / particulates in atmosphere (ignore reference to global dimming) **(1)** Unburned hydrocarbons are toxic / harmful **(1)** If reference to damage to ozone layer, global warming and / or acid rain then max **(1)**	Explosive Reactants wasted Air pollution	**2**

Question Number	Acceptable Answers	Reject	Mark
***19 (b)(iv)**	Global warming / climate change **(1)** Due to (increase in concentration of) CO_2 in the atmosphere / CO_2 is a greenhouse gas **(1)** Traps the heat **from the earth** / IR radiation (re-radiating) **from the earth (1)** If reference to damage to ozone layer then max **(2)** Photochemical smog is formed **(0)** NO_x is produced (by reaction of nitrogen & oxygen) **(1)** and reacts with (volatile) organic compounds in sunlight **(1)** Ignore references to increase in (of concentration) of H_2O in the atmosphere Ignore references to the effects of climate change	(heat) from the sun Global dimming due to complete combustion of hydrocarbon fuels Effects (e.g. reactions of unburned hydrocarbons) due to *incomplete* combustion	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(i)	The arrows show the movement of electrons **(1)** Single-headed/I denotes 1 electron and Double-headed/II denotes a pair of / 2 electrons /allow lone pair **(1)** Allow Explanations just in terms of electron movement in bond fission	Just stating homolytic and heterolytic fission	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(ii)	 Equation **(1)** two arrows correctly showing a homolytic fission **(1)** Here and in subsequent mechanisms the covalent bonds may be shown as lines or electron pairs or both The mechanism arrows may be shown on the same side or on different sides of the bond The single electrons need not be shown		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(iii)	$CH_4 + Cl^{\bullet} \rightarrow CH_3^{\bullet} + HCl$ **(1)** $CH_3^{\bullet} + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$ **(1)** Ignore state symbols and curly arrows. Ignore order of equations so these marks may be scored if an initiation step with fission of C – H bond in methane is given in c(ii)		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(iv)	Because a (chlorine) radical is regenerated / reformed / reproduced / recycled (by the propagation reactions each time a molecule of product is formed) **(1)** Allow methyl radical regenerated if initiation step with fission of C – H bond in methane is given in c(ii) and propagation order reversed Ignore references to chain reaction	radical is regenerated by UV light (chlorine) radical is a catalyst	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(v)	$CH_3^\bullet + CH_3^\bullet \rightarrow C_2H_6$ / $2CH_3^\bullet \rightarrow C_2H_6$ Ignore state symbols The single electrons need not be shown		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (d)	UV light does not have enough energy to (ALLOW 'cannot') break the C-H bond **(1)** So no H free radicals / atoms are formed (therefore cannot combine to form H_2) **(1)**	Just 'hydrogen' Just 'so no H_2 formed	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (a)	**(i) Structure** Lattice /close-packed **(1)** (or a diagram with at least 3 rows) positive ions or cations (allow metal ions) **(1)** delocalized electrons / sea of electrons **(1)** **(ii) Bonding** (Electrostatic) **attraction** between positive ions / cations (allow metal ions) and delocalized electrons / sea of electrons **(1)**	layers protons 'free' electrons	**4**

Question Number	Acceptable Answers	Reject	Mark
20 (b)	Any three from 1. Magnesium ion / Mg^{2+} (allow magnesium) has a larger charge (density) than the sodium ion (allow sodium) / Na^{+} some comparison of the ions is required **(1)** 2. magnesium ions / Mg^{2+} smaller than sodium ions **(1)** 3. Magnesium / Mg^{2+} contributes two / more electrons (per atom) to the "sea" of electrons **(1)** 4. magnesium ions / Mg^{2+} have greater attraction for the delocalized "sea" of electrons **(1)** Ignore reference to number of outer electrons in Mg / Na Any references to the bonding being ionic, covalent or intermolecular (max 2) Reverse argument can gain full marks	Just Mg^{2+} and Na^{+} More bonds	**3**

Question Number	Acceptable Answers	Reject	Mark
20 (c)	The delocalized electrons / sea of electrons **(1)** Flow (allow move / free to move) **(1)** (When a potential difference/voltage is applied) ‘Carry the current’ is not sufficient for the mark	‘free’ electrons	**2**

TOTAL FOR SECTION B = 60 MARKS

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